Sky and TELESCOPE

Swain

University of Illinois Observatory

In This Issue:

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NOVEMBER, 1957
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Sky and TELESCOPE

CHARLES A. FEDERER, JR., *Editor*
JOSEPH ASHBROOK, *Technical Editor*

Vol. XVII, No. 1 NOVEMBER, 1957

CONTENTS

COVER: The University of Illinois Observatory, located on the campus at Urbana, Illinois. It houses a 12-inch Warner and Swasey refractor. The building has recently been enlarged, as described in the adjoining column on this page.

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Unsolicited articles and pictures are welcome, bearing adequate return postage, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited material. Editorial assistants: Virginia K. Cox; Elizabeth C. Merrylees; William E. Shawcross. The principal articles are indexed in THE READERS' GUIDE TO PERIODICAL LITERATURE.

Astronomy at Illinois

GROUND was broken in 1896 for the University of Illinois Observatory at Urbana, pictured on the front cover of this issue. In the dome is a 12-inch equatorial refractor, made by Warner and Swasey, and there is also a 3-inch combined transit and zenith telescope for student instruction. The observatory has an outpost half a mile to the south, where a 4-inch Ross camera is used in Milky Way research.

This August, just before the American Astronomical Society met at Urbana, an addition was completed that filled in the southwest angle of the original building. It contains a seminar room, offices for the director and a secretary, and a radio astronomy laboratory in the basement. This new wing is at the left in the cover picture, its brickwork yet to mellow to that same rich tone as the original parts of the observatory. The old brick piers in the foreground serve as supports for portable telescopes and other instruments used by astronomy and navigation classes.

Despite its relatively small size and limited observational equipment, the University of Illinois Observatory has exerted a far-reaching influence on modern astronomy.

The first director at Illinois was G. W. Myers, from 1897 to 1900. In the first of these years he analyzed in great detail the light curve of the eclipsing binary Beta Lyrae, deducing the sizes, shapes, densities, and other properties of the two component stars. This was a remarkable achievement 60 years ago, and was praised by Dr. Otto Struve at the Urbana meeting this August, when he gave the Russell lecture on the problems of this famous double star.

In 1903 Joel Stebbins became director, and began a revolution in astronomical photometry. First pushing the light-sensitive selenium cell to its limits for measuring star brightnesses, he later developed the photoelectric cell to obtain extremely precise magnitudes and colors of stars. To this day he has remained in the forefront of this major branch of observational astronomy.

The third director was Robert H. Baker, well known both for his studies of the Milky Way and for his popular writings—his widely used textbook, *Astronomy,* is now in its sixth edition. Dr. Baker served from 1922 to 1951, being succeeded by the present director, George C. McVittie, a British-born astronomer who has made important contributions to the fields of cosmology and relativity.

The last three directors, whose terms span more than half a century, all attended the Urbana meeting, and may be seen together in the photograph by Walter J. Miller, S. J., on page 6.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 98th meeting of the American Astronomical Society at Urbana, Illinois, in August. Complete abstracts will appear in the Astronomical Journal.

Revision of Rowland's Tables

In 1895, the Johns Hopkins physicist, Henry A. Rowland, began publication of an extensive catalogue of the Fraunhofer absorption lines in the spectrum of the sun. These classic tables were revised in 1928 by W. S. Adams and his coworkers at Mount Wilson Observatory.

Now the second revision of Rowland's tables is being prepared jointly by M. Minnaert at the Utrecht Observatory and Charlotte Moore Sitterly at the National Bureau of Standards. The identification of the many thousands of spectral lines, their wave lengths, the multiplet attributions, and the lines' equivalent widths are being checked or newly determined. It is hoped that the manuscript will be ready for the general assembly of the International Astronomical Union at Moscow next year.

In describing this program, Dr. Minnaert discussed the particularly difficult problem of determining equivalent widths of the lines that are crowded together in the ultraviolet region. In fact, they overlap so much that the true continuous background of the solar spectrum can not be observed. The background can be inferred, however, from special study of the wings of strong lines of iron and other elements, which differ markedly from the classical theory. Dr. Minnaert finds that in the region between wave lengths 3550 and 3650 angstroms the true background is about 40 per cent higher than the highest points observed.

This astronomer from the Netherlands, M. G. J. Minnaert, was guest speaker at the society dinner at Urbana. Director of Utrecht Observatory, he is an authority on the sun's spectrum, eclipses, and stellar atmospheres. He is author of the popular book, "Light and Colour in the Open Air."

Luminosities of Mira Stars

The long-period variables, of which Mira (ο Ceti) is a well-known example, are giant red stars whose brightnesses change by five magnitudes, on the average, in cycles of the order of a year. Phillip C. Keenan, of Perkins Observatory, reported on his observations of the spectra of 20 such stars with the 60-inch reflector at Mount Wilson. His purpose was to determine their intrinsic luminosities, as indicated by the intensities of spectral lines that can serve as luminosity criteria.

A provisional calibration of the luminosity sequence shows that Mira variables of spectral class *M*2e, with an average period of 200 days, attain visual absolute magnitude −2.3 at maximum light. Later spectral types have lower luminosities and longer periods; thus, a typical *M*6e variable has a 360-day period and a visual absolute magnitude of 0.0.

Dr. Keenan finds that some long-period variables, such as RT Cygni and Z Ophiuchi, appear spectroscopically to be at least as luminous intrinsically as supergiants like Betelgeuse. The spectrum of Z Ophiuchi is noteworthy for the weakness of its calcium lines.

Nova Binary Star

Normally a 10th-magnitude star, the recurrent nova T Coronae Borealis has twice brightened briefly to the 2nd magnitude, in the years 1866 and 1946. It is also a close double star, the blue component responsible for the nova outbursts being accompanied by a giant red star of spectral type g*M*3.

Many new facts concerning this unusual system have been revealed in a spectroscopic study by Robert P. Kraft, Goethe Link Observatory, using the 100-inch Mount Wilson reflector. The period of binary revolution is 227.8 days. The motion of the red star was detected by R. F. Sanford a decade ago, but Dr. Kraft has now succeeded in finding spectral features of the blue star. Its hydrogen-beta line is bright, and shows a range in radial velocity of 70 kilometers per second.

From this it appears that the *M*-type star is about four times as massive as the sun, and the nova component has a mass of about 2.5 to 3 suns. The binary system is dynamically unstable, material flowing from the red star to the blue one, forming a ring or shell around the latter. In addition, a large and very tenuous gaseous envelope surrounding the binary system as a whole is proposed by Dr. Kraft to account for the presence of certain spectrum lines of doubly ionized neon.

This model of the T Coronae Borealis system closely resembles present views of the nature of the variable stars SS Cygni and AE Aquarii, and Dr. Kraft believes that all three systems belong to the same homogeneous physical group.

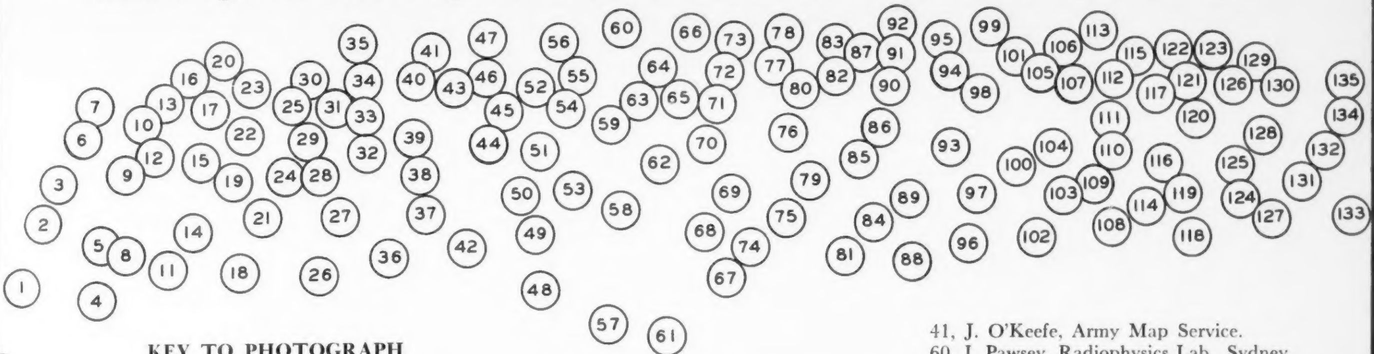
Infrared Observations of Planets and Satellites

At McDonald Observatory, Gerard P. Kuiper has been continuing to observe bodies in the solar system with the 82-inch reflector in infrared light. He has measured the polarization of the light of Venus at wave lengths of one and two microns; the results appear to rule out water droplets as forming the planet's clouds (*Sky and Telescope*, November, 1954, page 20). Instead, Dr. Kuiper suggests the clouds of Venus may be made of particles of polymerized carbon suboxide (C_3O_2).

Striking differences among the four Galilean satellites of Jupiter have been

Another overseas visitor at the Urbana meeting was A. R. Hogg, who is a staff member of the Australian Commonwealth Observatory, on Mt. Stromlo near Canberra. He has been an active observer of southern double stars, but more recently his main field of interest has been photoelectric photometry.

Members and guests at the 98th meeting of the American Astronomical Society, University of Illinois, Urbana, August 18-21, 1957.



KEY TO PHOTOGRAPH

1 C, 2 L, 3 T, 4 R, 5 W, 6 J, 7 J, 8 W, 9 C, 10 H, 11 W, 12 W, 13 H, 14 H, 15 W, 16 R, 17 H, 18 S, 19 C, 20 W, 21 R, 22 S, 23 S, 24 R, 25 M, 26 R, 27 R, 28 W, 29 H.

30 C, 31 D, 32 H, 33 M, 34 K, 35 S, 36 H, 37 F, 38 G, 39 R, 40 A, 41 O, 42 E, 43 W, 44 H, 45 A, 46 F, 47 H, 48 W, 49 E, 50 H, 51 H, 52 S, 53 S, 54 K, 55 W, 56 M, 57 H, 58 M, 59 H.

60 P, 61 S, 62 F, 63 M, 64 W, 65 W, 66 B, 67 K, 68 M, 69 H, 70 C, 71 H, 72 W, 73 H, 74 K, 75 K, 76 S, 77 M, 78 D, 79 S, 80 M, 81 M, 82 A, 83 L, 84 S, 85 S, 86 M, 87 B, 88 K, 89 S.

90 B, 91 M, 92 S, 93 G, 94 U, 95 H, 96 S, 97 M, 98 S, 99 C, 100 V, 101 B, 102 S, 103 R, 104 K, 105 M, 106 L, 107 M, 108 S, 109 B, 110 F, 111 C, 112 M, 113 H, 114 B, 115 P, 116 Y, 117 S, 118 P, 119 S.

120 F, 121 M, 122 C, 123 R, 124 G, 125 B, 126 M, 127 E, 128 D, 129 M, 130 B, 131 H, 132 S, 133 M, 134 K, 135 K.

ALPHABETICAL LIST

40, H. Abt, Ye; 82, H. Albers, B; 45, L. Aller, M.

66, H. Babcock, MWP; 114, J. Bartlett, Y; 90, W. Beardsley, A; 125, W. Bidelman, Li; 109, D. Billings, HA; 87, V. Blanco, CIT; 101, R. Bless, M; 130, D. Brouwer, Y.

111, D. Camp, I; 30, J. Caplan, Ad; 99, E. Carpenter, Steward Obs.; 70, J. M. Chamberlain, AMH; 122, J. W. Chamberlain, Ye; 19, G. Clemence, N; 1, Mrs. Clemence; 9, H. Crull, B.

128, D. Dewhirst, Cambridge Obs., England; 78, A. Dollfus, Paris Obs., France; 31, J. Douglas, Y.

127, F. Edmondson, I; 49, Mrs. Edmondson; 42, Miss M. Edmondson.

120, C. Federer, H; 110, J. Fernie, I; 37, R. Fleischer, RPI; 46, K. Franklin, AMH; 62, O. Franz, NW.

38, A. Gehrels, I; 93, Miss G. Gjellestad, Bergen, Norway; 124, R. Grenchik, V.

44, R. F. Haupt, N; 51, Mrs. Haupt; 71, R. W. Haupt; 131, J. Heard, DD; 13, C. Hemenway, Union; 14, Mrs. Hemenway; 10, D. Hemenway; 57, Miss S. Hemenway; 47, P. Herget, Cin; 36, Mrs. Herget; 113, A. Hewish, Cavendish Lab., Cambridge, England; 32, Miss S. Hill, Wellesley; 95, W. Hiltner, Ye; 17, A. Hoag, N; 59, A. Hogg, Mt. Stromlo Obs., Australia; 69, H. Horak, K; 29, C. Huffer, Wisconsin; 50, Mrs. Huffer; 73, J. Hynek, S.

7, A. Joy, MWP; 6, Mrs. Joy.

104, E. Kane, Detroit, Mich.; 88, Mrs. Kane; 34, G. Keller, Perkins Obs.; 75, I. King, Ill; 74, Mrs. King; 67, D. King; 54, R. Kraft, I; 134, J. Kraus, Ohio State; 135, G. Kuiper, Ye.

106, W. Liller, M; 83, P. Lind, Ad; 2, Miss J. Lucas, Ill.

129, T. Matthews, MWP; 121, Mrs. A. Matthews, MWP; 107, S. McCuskey, CIT; 63, D. McNamara, Brigham Young; 58, G. McVittie, Ill; 68, Mrs. McVittie; 105, T. Menon, H; 97, J. Merrill, Pennsylvania; 133, P. Merrill, MWP; 81, Mrs. P. Merrill; 25, M. Miller, S. J., Rochester, N. Y.; 33, W. Miller, S. J., Fordham; 56, R. Minkowski, MWP; 86, M. Minnaert, Utrecht, Holland; 91, W. Mitchell, M; 80, W. Moore, Louisville; 112, G. Moreton, Pomona, Calif.; 126, W. Morgan, Ye; 77, G. Mulders, ONR.

41, J. O'Keefe, Army Map Service.

60, J. Pawsey, Radiophysics Lab., Sydney, Australia; 118, B. Peery, M; 115, P. Pesch, Ye.

27, E. Rabe, Cin; 21, Mrs. Rabe; 26, Miss I. Rabe; 4, Miss K. Rabe; 39, R. Redlich, RPI; 103, R. Riddle, Purdue; 24, Miss M. Risley, Randolph-Macon; 123, W. Roberts, HA; 16, M. Rogers, Ill.

108, J. Schopp, Missouri; 102, Mrs. Schopp; 119, L. Searle, DD; 117, C. Seyfert, V; 92, A. Shatzel, Ad; 85, B. Sitterly, American Univ.; 96, Mrs. C. Sitterly, Nat'l. Bur. of Standards; 35, H. Smith, Y; 132, A. Spitz, S; 79, R. Sprague, K; 53, J. Stebbins, Li; 76, J. Stokley, Michigan State; 89, K. Strand, NW; 84, Mrs. Strand; 61, Miss C. Strand; 18, Miss J. Streeter, ONR; 22, B. Stromgren, Ye; 98, O. Struve, Le; 52, C. Swanson, Army Ballistic Missile Agency, Huntsville, Ala.; 23, G. Swenson, Ill.

3, S. Trehan, Ye.

94, A. Upgren, M.

100, M. Vardya, M.

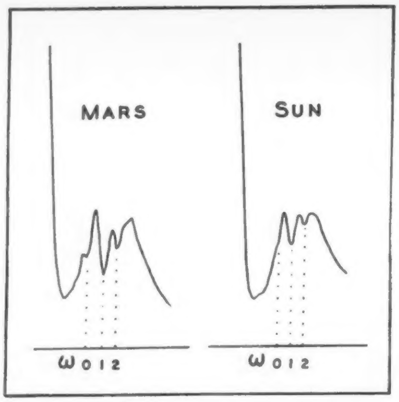
28, N. Wagman, A; 11, Mrs. Wagman; 55, H. Weaver, Le; 72, L. White, ONR; 20, R. Whitehurst, Alabama; 43, G. Wilkins, N; 5, Mrs. Wilkins; 8, M. Wilkins; 64, R. Wilson, Naval Res. Lab.; 65, Mrs. Wilson; 48, Miss K. Wilson; 12, S. Wyatt, Ill; 15, Mrs. Wyatt.

116, K. Yoss, Louisiana State.

A, Allegheny; Ad, Adler Planetarium; AMH, American Museum–Hayden Planetarium; B, Butler; Cin, Cincinnati; CIT, Case Institute of Technology; DD, David Dunlap; H, Harvard; HA, High Altitude; I, Indiana; Ill, Illinois; K, Kansas; Le, Leuschner; Li, Lick; M, Michigan; MWP, Mount Wilson–Palomar; N, Naval Observatory; NW, Northwestern; ONR, Office of Naval Research; RPI, Rensselaer Polytechnic Institute; S, Smithsonian Astrophysical; V, Vanderbilt; Y, Yale; Ye, Yerkes.

found from intensity tracings of their spectra with an infrared spectrometer. Satellites I and IV reflect sunlight with little change, but for III and especially II the spectrum is markedly fainter in the range from 1.5 to 2.5 microns. This effect would be produced if the surfaces of satellites II and III were covered with snow. The high reflectivity of II in visual light and its color fit this hypothesis, while III, which is darker, may be covered with snow contaminated by silicate dust. At Jupiter's distance from the sun, the rate of evaporation of snow would be very slow, even if exposed to a vacuum.

In infrared spectrum tracings of Mars, Dr. Kuiper has observed three absorption bands of carbon dioxide near two microns, finding them stronger than can be explained by the amount of this gas in the earth's atmosphere. This fact was established by a comparison of the tracings reproduced here, which were made when the light of Mars and the sun passed through nearly equal thicknesses of our air. At the left each tracing shows the same deep absorption band at 1.8 microns produced by water vapor in the earth's atmosphere. The three CO_2 absorptions are ω_0, ω_1, and ω_2, at wave lengths 1.957, 2.006, and 2.057 microns, respectively. Relative to the sun's spectrum, the Martian bands are stronger, in approximately the same ratio as were weaker bands of carbon dioxide at 1.6 microns discovered by Dr. Kuiper in 1947. Thus the new results corroborate the earlier evidence for CO_2 as a constituent of the Martian atmosphere.



These spectrum tracings by G. P. Kuiper show the added strength of carbon dioxide bands in the spectrum of Mars. Yerkes-McDonald Observatories chart.

Other McDonald observations confirm that Saturn's rings are composed of snow particles, and reveal new features in the infrared photographic spectra of Jupiter and Uranus.

Brighter Artificial Satellites?

Because a 20-inch American artificial satellite is expected to be about 6th magnitude at perigee and about 10th at apogee, its faintness will be an important difficulty in optical observations. Armand N. Spitz, of the Smithsonian Astrophysical Observatory, and Raymond H. Wilson, Jr., Naval Research Laboratory, propose that the satellite be a polyhedron, with plane mirror surfaces.

Illuminated by the sun, such a satellite would be visible as a series of light flashes three or more magnitudes brighter than the reflection from a sphere. Dr. Wilson has computed that a plane mirror surface only one centimeter in area, situated about 300 miles from the observer and reflecting sunlight face-on, could appear as bright as a 1st-magnitude star.

The rate of occurrence of the flashes would depend on the number of plane faces and the speed of the satellite's rotation. In an alternative design, plane facets would be added to the original sphere, so the satellite would remain visible during the intervals between flashes, which would occur with a frequency of several times a second to several times a minute.

Streamlining of the satellite's surface is not necessary, because of the low air resistance at the heights where it will travel in its orbit. While being carried upward from the earth, the satellite will be enclosed in the third stage of the Vanguard rocket, so during that time also its shape will not affect drag.

Both speakers pointed out that a flashing body might be easier to recognize as a satellite by visual observers, and the flashes could tell how fast it was rotating.

The present director of the University of Illinois Observatory, George C. McVittie, stands at the left in this picture. Talking with him are two of his predecessors in office, Joel Stebbins (center), who was director from 1903 to 1922, and Robert H. Baker, from 1922 to 1951. Photograph by Walter J. Miller, S. J.

Punch-Card Observing

At the Flagstaff, Arizona, station of the U. S. Naval Observatory, an observer at the 40-inch reflector is assisted by automatic devices that punch the data of each photoelectric observation directly onto IBM cards. These can then be sent to headquarters in Washington, D. C., for processing by IBM 650 computing machines.

Two separate analyzer sections of the photometer may be readily interchanged, one being used for observations of star brightnesses in three selected colors, the other for polarization measurements. The photometer output is fed through amplifiers to an integrator, and the result is displayed on a strip-chart recorder.

But the recorder is also equipped with a digitizer and readout device which punches on IBM cards the amount of each deflection of the recording pen, with an accuracy of a thousandth of the full-scale deflection. Observations of a particular star are made automatically in sequence after the telescope is set by the observer. Fifteen to 20 stars can be observed in an hour because the telescope is so easily pointed from one part of the sky to another. (See *Sky and Telescope,* November, 1956, page 4.)

Interstellar Gas

Sidney van den Bergh, of Perkins Observatory, calls attention to a surprising property shared by both the Milky Way galaxy and the Andromeda nebula: the relatively small amount of interstellar gas in the spiral arms. While ejection of matter from stars provides some such gas, a larger quantity is consumed in the process of star production. Were no external supply available, the gas in the solar vicinity would be exhausted in about 7×10^8 years.

Furthermore, the amount of gas now in the galactic nucleus is only about 1/250 or 1/300 that which should have been ejected from the stars there during the five-billion-year history of our galaxy.

Dr. van den Bergh suggests that both these points can be explained by a continuing escape of gas from the nucleus, the gas moving outward along the spiral arms. The present rate of gas loss from the central part of the galaxy would match the rate at which the interstellar gas is being removed from the spiral arms by star formation.

The Seeing at Kitt Peak

A. B. Meinel, of the new National Astronomical Observatory, has encouraging data on the quality of the seeing on Kitt Peak, Arizona, one of the five sites in the Southwest being tested for the location of 80-inch and 36-inch reflectors (*Sky and Telescope,* August, page 482).

The seeing on Kitt Peak, an isolated mountain mass rising to 6,875 feet, with

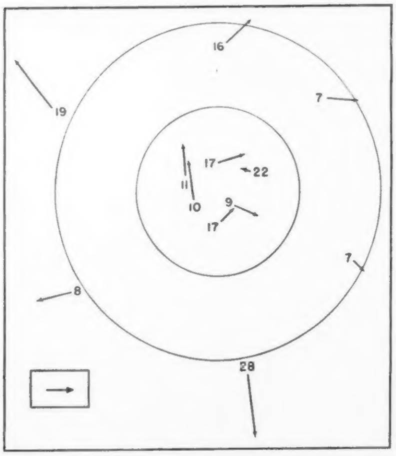
a 70-acre level summit, has proved of surprising excellence. This was shown by the small amount of scintillation "noise" on the photoelectric records of Polaris, which was continually observed with a 6-inch monitor telescope. The Kitt Peak observers believe that the seeing is better there than at any other observatory where they have worked. Clouds are rare, especially in the summer, when there is less cloudiness than at nearby Tucson. Another advantage is the smallness of the day-to-night temperature range – only 3.1 degrees centigrade in winter and 6.5 degrees in summer.

Thirty tons of equipment and a housing trailer have been hauled to the summit of Kitt Peak over a primitive bulldozer trail which has grades as steep as 78 per cent. In July, a 16-inch Cassegrainian reflector, equatorially mounted on a truck, was put into service. The seeing tests at Kitt Peak and at the other stations under survey will continue well into the future.

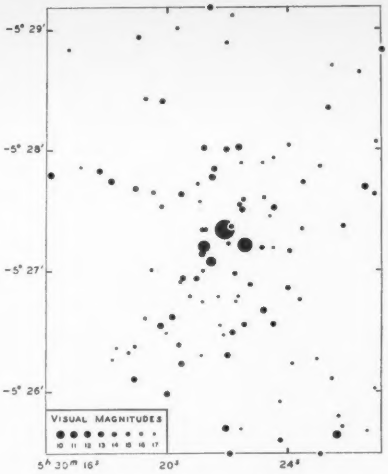
Expanding Star Cluster in Orion

The compact cluster of faint stars surrounding the Trapezium, in the heart of the Orion nebula, is growing in size at the rate of one part in 300,000 per year, according to the work of K. A. Strand, director of the Dearborn Observatory, Northwestern University. This expansion indicates a common origin for the cluster stars only 300,000 years ago, with an uncertainty of 40,000 years.

Dr. Strand's findings illustrate the importance of positional observations of the stars over long intervals. He made measurements of recent Orion photographs taken with the 40-inch Yerkes refractor, and compared them with similar plates



Note the predominance of outward motions in this Dearborn Observatory plot, in which the circles centered on the Trapezium have radii of five and 10 minutes of arc, respectively. For the number of stars indicated by the adjoining label, each arrow gives the average proper motion; the arrow in the box has the unit length of one second of arc in 1,000 years.



This map of the surroundings of the region of the Trapezium (Theta Orionis) includes stars to visual magnitude 17.5. Dr. Strand based the chart on infrared photographs taken at Lick Observatory and the Flagstaff station of the U. S. Naval Observatory. The coordinates are for the epoch 1900.

taken 50 years earlier by G. W. Ritchey and J. A. Parkhurst. Since all the exposures were made through yellow filters on yellow-sensitive plates, the nebulosity was so weakened that it did not interfere with the measuring of the star images.

From 10 pairs of plates with 50-year intervals, precise proper motions were determined for 200 stars of the 14th visual magnitude and brighter, within an area roughly half a degree square. These measurements were made with respect to 16 reference stars of average magnitude 11 that belonged to the cluster. The configuration of the 16 stars turned out to be one part in 6,000 larger on the recent plates than on the early ones.

Was this change due to an actual radial expansion of the cluster? One possible alternative was that the apparent expansion was merely the result of random motions of the reference stars. However, new measurements with another set of 25 reference stars showed the same enlargement. Other tests demonstrated that there was no instrumental effect, such as a progressive increase in the focal length of the Yerkes telescope, nor was there a gradual shrinkage of the emulsion on the old plates. When Dr. Strand compared two pairs of photographs of the Pleiades taken 50 years apart with this same telescope, no expansion was detected.

By comparing his new very precise proper motions of the cluster stars with previously published radial velocity values, Dr. Strand computed 600 parsecs as the distance of the cluster. This is considerably greater than the 400-parsec result derived photometrically by P. P. Parenago in Russia, and by W. A. Hiltner and H. L. Johnson in the United States. But Dr. Strand believes the latter determinations are too small because the *A*-type stars in the Orion cluster are actually more luminous than their colors imply.

Within five minutes of arc of the Trapezium there are seen about 300 stars brighter than visual magnitude 17.5. When allowance is made for stars hidden by patches of interstellar obscuring material, the number becomes about 400, corresponding to a total mass of some 350 suns – a minimum value. This is nearly the same as the mass of the Pleiades cluster, but only within one-eighth of the volume.

With an age of only 300,000 years, the Trapezium cluster is among the very youngest known. This is confirmed by the color-magnitude diagram of its members constructed by Dr. Strand, showing to an exaggerated degree the peculiarities found by Merle Walker for the young cluster NGC 2264 (*Sky and Telescope*, October, 1954, page 426), which is now believed to be three million years old.

The color-magnitude diagram of the Trapezium cluster has a broad, continuous sequence of stars from spectral type *O*6 to type *K*5 V. But the stars later than *B*3 are brighter than standard main-sequence stars, showing that they may still be contracting gravitationally.

QUESTIONS... FROM THE S+T MAILBAG

Q. To what distance does the absolute magnitude of a star correspond?

A. The absolute magnitude of a star is the magnitude it would appear to have if viewed from a standard distance of 10 parsecs (32.6 light-years).

Q. When can the constellation Crux (the Southern Cross) be seen from southern Florida?

A. It is best placed for view when the quadrilateral of Corvus is on the meridian, Crux then being 40° to the south. This can happen during hours of darkness from January until June, specifically at 11 p.m. local time at the beginning of April, and 9 p.m. at the beginning of May.

Q. What is meant by the radial velocity of a star and why can it have positive and negative values?

A. Radial velocity is the speed at which a star approaches us (negative value) or recedes (positive value); it is that part of the star's motion that lies along our line of sight to the star.

Q. How is radial velocity measured by astronomers?

A. By the Doppler shift in the positions (wave lengths) of lines in the spectrum of the astronomical body. Motion of approach shifts the spectral lines to the violet side of their normal positions, recession shifts them toward the red. The amount by which a spectral line is displaced is directly proportional to the radial velocity. W. E. S.

A Seeing Compensator Employing Television Techniques

JOHN H. DEWITT, ROBERT H. HARDIE, and CARL K. SEYFERT, *Dyer Observatory, Vanderbilt University*

THE BASIC PROBLEM in photographing the surface of a planet is overcoming the disturbances in the earth's atmosphere. It has always been possible to see more detail visually than can be recorded photographically through the same telescope. This is due to the fact that the eye can distinguish between moments of atmospheric steadiness and other instants when the image is blurred.

There has long been a pressing need for a photographic method that can record the fine planetary detail revealed to experienced visual observers in instants of excellent seeing. This could be accomplished by making extremely short, high-contrast exposures with a moderate-size telescope. Instruments of up to 24 inches are more likely to produce good images during times of atmospheric unsteadiness than are larger telescopes. Since smaller apertures ordinarily require longer exposures, some method of image intensification is required. The apparatus described here, which uses a closed-circuit television system on a 24-inch reflector, not only achieves the desired image intensification and added contrast but compensates electronically for the movement of the planetary image due to seeing.

The Orthicon pickup tube used in television cameras is a very powerful light amplifier, if the illumination on the photocathode is sufficient to overcome beam noise. This condition is satisfactorily obtained with the Dyer 24-inch reflector on the planets Venus and Jupiter, and also Mars when it is near opposition.

The telescope is used in its Cassegrainian form, and light passes through a negative lens to form an image of Jupiter about half an inch in diameter. As the block diagram shows, the beam of light is divided by a dichroic filter so that about 60 per cent is fed to the photocathode of the Orthicon, while the remainder forms a monitor image on two slits placed at right angles to each other.

The planetary image on the photocathode produces on the monitor Kinescope a picture approximately four times larger and much brighter than the original. The modified TV circuit is so arranged that the system can be turned on at intervals of 1/30 second, the time corresponding to one vertical sweep. Other circuits allow the Orthicon target to store for 1/15, 2/15, or 4/15 second before the single-sweep discharge is applied. Such accumulation of electrons by storage on the target greatly increases the sensitivity to faint light.

A primary purpose of the new device is to compensate for the movements of the image as a whole during the exposure. To achieve this, four deflection coils are placed around the image section of the Orthicon at 90-degree intervals. Currents of the proper phase and strength pass

The seeing compensator is the T-shaped device mounted at the Cassegrainian focus of the 24-inch reflector. In the cross of the T is a beam splitter that diverts part of the planet's light down the side arm to the Orthicon television pickup tube. The remaining light continues along the top of the T to crossed slits and two photocells, which detect image shifts and provide for their compensation. Cables run from the telescope assembly to a cabinet for the power supply and other electronic components. The light-colored disk on the cabinet is the Kinescope screen, where the intensified image is displayed. Photos by Jeanne-Gordon Studio.

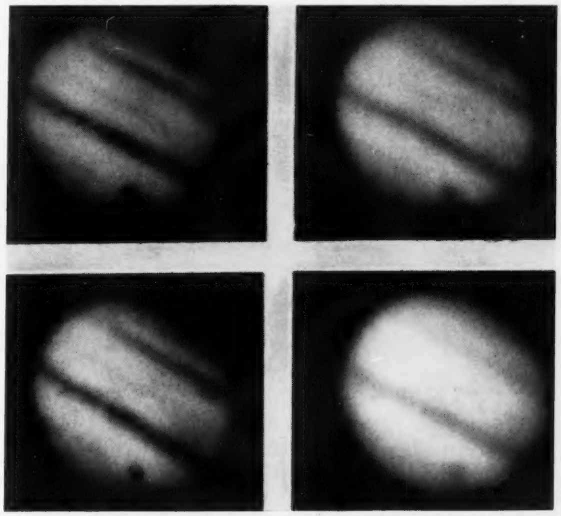
through these coils, and deflect the electron stream between the photocathode and target in such a way that the image remains centered on one spot on the target, even though the optical image on the photocathode may wander across 1/10 the diameter of the field of view. The currents that actuate the deflection coils come from two 1P21 photocells, which are placed behind the two slits at the second or monitor image of the planet.

These photocurrents are directly proportional to the image position in x and y co-ordinates along each slit. The currents pass through d.c. amplifiers which use vacuum tubes and high-power transistors, and then are fed to the image-section deflection coils. The coils must be aligned carefully in order to have their action just offset the wandering of the optical image. This is done by adjusting the deflection-compensator amplifier gains so that the image is stationary. One simple way is to shake the telescope and adjust the gains until the image movement is compensated!

The seeing compensator, or "tranquilizer" as it has been called, is pictured here, as mounted on the 24-inch reflector. The cabinet holds the power supplies, synchronizing generator, amplifiers, and monitor Kinescope. To photograph the image we use a 35-millimeter camera (not shown), which is mounted about nine inches in front of the television screen.

It has been a relatively short time since the apparatus became ready for operation, and up to September its principal use was to take pictures of Jupiter, samples of which are reproduced here. The images on this page were taken through the apparatus with the compensator operating (left), and with it turned off (right).

A television circuit of this type can utilize the full defining power of the telescope, because it employs more scanning lines than does present-day commercial TV. In our apparatus, the image of a planet contains 200 scanning lines which, in the case of Jupiter, are spaced 0.2 second of arc apart—about the theoretical resolving power for a 24-inch telescope. It seems possible to see readily on the TV screen as much as an experienced observer does at the telescope eyepiece. Increased contrast can be obtained through the electronic system, rendering faint detail much more apparent than is the case with direct telescopic viewing.

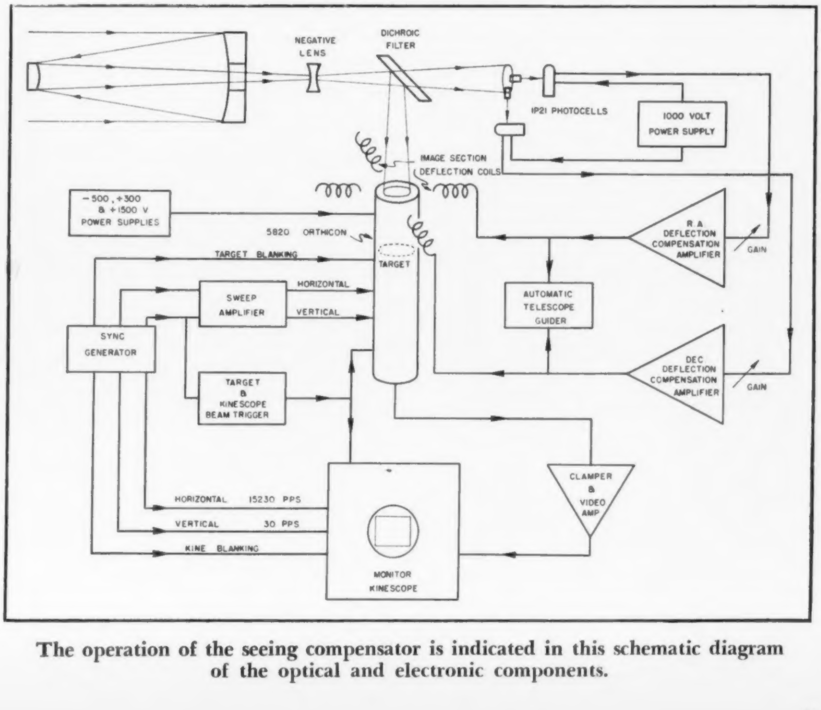


Photographs of Jupiter on the Kinescope screen, with the shadow of one of its larger moons seen against the planet's disk. The pictures at the right were taken with the seeing compensator turned off, those at the left with it in operation. These examples do not fully exploit the definition of the apparatus, but they demonstrate the steadying effect of the compensator. Dyer Observatory photographs.

In addition to photographing Jupiter, the apparatus has been used successfully as an automatic guiding device. This fall and winter it is planned to observe Venus, in an attempt to evaluate its rotation period; also we expect to photograph Mars at its next opposition.

Another project that appears feasible is to test the coherence of seeing—the tendency of two separated stars to be simultaneously affected the same way by seeing. The test could be made by steadying the image of Jupiter and examining the fluctuations of its satellites at various angular distances from the planet.

Our apparatus was developed as a joint project of Vanderbilt University and Station WSM-TV in Nashville, Tennessee.



The operation of the seeing compensator is indicated in this schematic diagram of the optical and electronic components.

JUPITER'S CLOUDS

It is widely agreed by astronomers that the atmosphere of Jupiter above the cloud layer that veils the planet consists mainly of hydrogen and helium, with small quantities of methane and ammonia. The clouds themselves probably are made up of particles of frozen ammonia.

P. Squires, in Australia, now finds that the equatorial clouds of Jupiter are not flat-topped, as had been previously assumed, but are domed like terrestrial cumulus clouds. The cumuliform tops reach about 20 or 30 kilometers above the main cloud deck. Dr. Squires reached these conclusions from a theoretical analysis of observations, made several years ago by Seymour Hess, of the intensity of spectrum bands of methane and ammonia over different portions of the disk of Jupiter.

The new study indicates that the temperature at the level of the main deck is considerably higher than −150° Fahrenheit. However, with the introduction of this new and more complicated model of Jupiter's clouds, it is no longer possible to deduce an accurate temperature for the cloud surface from the spectroscopically measured quantity of ammonia.

Dr. Squires, who is a staff member of the division of radiophysics, Commonwealth Scientific and Industrial Research Organization, Sydney, Australia, reported his findings in the *Astrophysical Journal.*

A Probable Meteorite Fall in Brazil

Vincent Menezes

This fragment of the meteorite was found near Ibitira. Its rough dimensions are 4 by 6 by 7 inches. The dark, shiny surface is part of the crust; the lighter portion at the left is where a sample was taken for analysis. Photo by Geraldo C. Lessa.

On the late afternoon of June 30, 1957, between 5:00 and 5:30 p.m. local time, a great fireball passed northwestward over the central part of the state of Minas Gerais, Brazil, and sounded as if it were exploding in the air, frightening nearby villagers.

As soon as our amateur group, the Center for Astronomical Studies of Minas Gerais, learned of the event, we appealed through the local press and by letter for observers' reports. Of the 32 letters received, we selected the best 19 and made field trips with notebooks, maps, and compasses, to interview the writers and others who had seen the phenomenon.

Observers in this city, Belo Horizonte, first saw the fireball at an altitude of 50 degrees, falling toward Martinho Campos and seeming to explode in the air. Other persons, about 160 kilometers to the southeast of the end point of the fireball, saw the breakup take place about five degrees above the horizon. From estimates of this kind it appears that the visible trajectory came to an end about 10 or 12 kilometers above the earth's surface.

The fireball was seen as a reddish, egg-shaped body, which became silvery in color, but I think the latter hue was seen after the disintegration. There was a noise like the reverberation of thunder. The accompanying sketches show the long white train which the meteor left behind it, as it appeared at first and after it had become distorted by upper-air winds. The train seemed straight to observers directly beneath it, and as a parabolic arc to those who viewed it from the side. The straight train became sinuous, and then divided in two, taking on a V-like shape, its color becoming silvery blue and light gray.

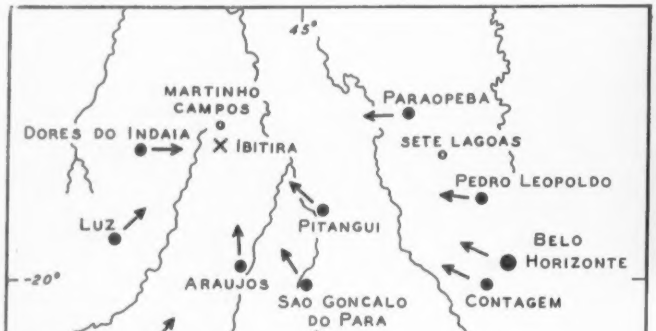
Several kinds of evidence fixed the end point of the trajectory in the county of Martinho Campos, near Ibitira, a village of some 200 inhabitants, on the Minas Gerais state railroad 213 kilometers from Belo Horizonte. The directions in which the trail was seen by different observers are shown by arrows on the map, and they tend to converge on Ibitira.

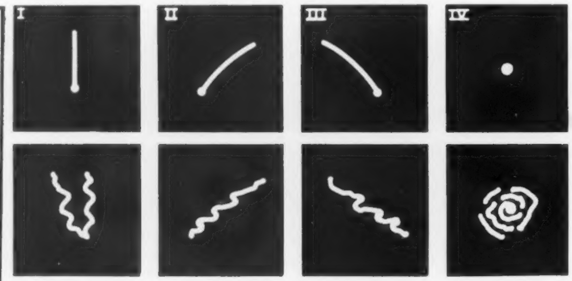
At the Monjolo farm near Ibitira, the characteristic thunder sound was heard, followed some seconds later by a whistling like a falling bomb, and immediately thereafter by the noise of something like a stone striking the ground. A young man on the farm looked at once toward the direction from which this sound seemed to come, and saw cattle running down a hillside pasture into the valley.

At first no meteoritic fragment could be located, for there were too few people to scour the many acres of pasture, which are covered by creeping vegetation. Later, however, the small piece shown in the picture was found in Ibitira near the point of the fall predicted by my analysis. It lay in a hole in the ground about 10 inches deep and eight in diameter.

This object has a brilliant black crust, and a light brown, slightly porous interior. It was brought to the Institute of Technological Researches, Belo Horizonte, for chemical analysis. Preliminary results show the presence, in decreasing order of abundance, of silicon, magnesium, iron, aluminum, calcium, chromium, and titanium. Spectroscopic examination reveals lines of sulphur and manganese. Contrary to expectation, there were no signs of sodium, nickel, or cobalt.

These facts make it probable that this object is actually a stony meteorite. A further search is intended to recover the fragment that we suppose must have fallen on the Monjolo farm.

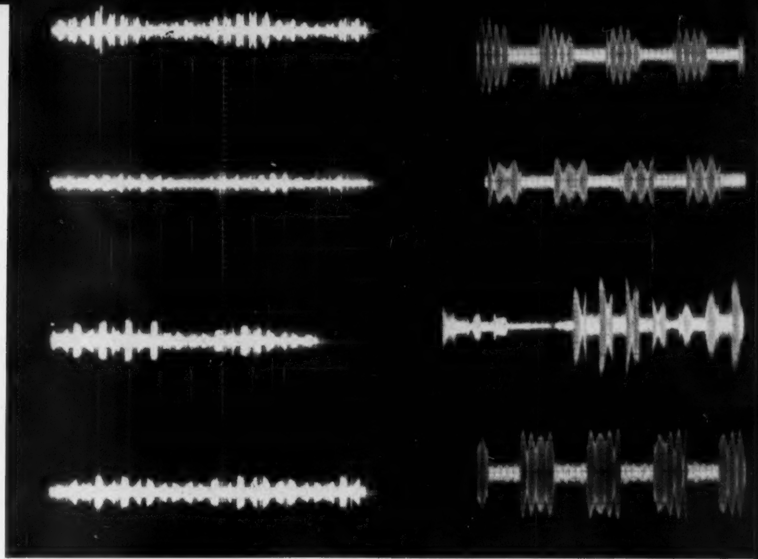




Above: The upper row of sketches shows the original appearance of the meteor train, and the lower row the effect of wind distortion soon afterward, for observers looking toward: I, the northwest; II, the northeast; III, the southwest; and IV, from Ibitira.

Left: Observers' reports of the direction of the end point of the meteor's trail are indicated by the arrows on this map. At Ibitira, the meteor seemed to be coming directly toward the observer.

ARTIFICIAL SATELLITE NO. I



These are photographs of the screen of an oscilloscope fed by a short-wave receiver, showing 20.005-megacycle pulses from the Russian satellite, during the night of October 5, 1957, one day after the launching. The various pulse patterns may indicate actual telemetering, or merely effects of propagation through the atmosphere. Photos by Robert Slavin and G. R. Miczaika, Geophysics Research Directorate, Air Force Cambridge Research Center, Bedford, Massachusetts.

THE ARTIFICIAL-SATELLITE AGE began on October 4, 1957, when a Russian test vehicle started to circle the earth 15 times a day.

According to a preliminary analysis by German astronomers at Bonn Observatory using early observations, the new moonlet was launched that day about 20^h Universal time from a point somewhere in central Asia.

In *Soviet Aviation*, Prof. Y. A. Pobedonostsev stated that the three-stage launching rocket attained a speed of about 4,500 miles per hour in the first two minutes. When the first stage dropped away, the vehicle was moving upward at a 45-degree angle. At second-stage burnout, the speed was nearly 12,000 miles an hour. Unpowered flight lasted until horizontal motion was achieved about 625 miles from the launching site; then the third-stage motor took over to boost the speed to approximately 18,000 miles per hour before ejection of the artificial moonlet.

During the first days of the satellite, conflicting reports and speculation were mingled with facts, and the confusion has been only partly cleared away at this writing. But we know, for instance, that the satellite is a sphere 22.8 inches in diameter, with the surprisingly large total weight of 184 pounds. According to Radio Moscow on October 5th, the period of orbital revolution was 96.2 minutes, implying an average height of 370 miles.

As soon as the existence of the moonlet was revealed, MOONWATCH teams were alerted; then it was learned that no favorable passages over the United States would occur for a number of days. Like the projected American satellites, the Soviet one presumably can be seen only during or near morning and evening twilight, when it may be viewed as a sunlit speck against a fairly dark sky; it would be invisible at other times.

American observations, at least initially, were limited to the radio signals transmitted from the satellite, the continuous beeping audible over a range of thousands of miles because of the great altitude of the satellite. The transmitters, which consumed one watt of power, radiated pulses of 0.3-second duration, followed by an equal interval of silence, at 20.005 and 40.002 megacycles (wave lengths of about 15 and 7.5 meters). The pulses at one frequency occurred simultaneously with the pauses on the other. By October 8th, these transmissions appeared to be growing weaker.

The great early strength of the signals made them easily detectable by amateur operators, and they were received by many members of the American Radio Relay League. The 10 Minitrack stations organized by NRL to monitor American satellites at 108 megacycles required hasty conversion of antennas and receivers to pick up the Russian frequencies.

During a passage of the satellite, the steady beeping could be followed for 25 to 35 minutes. At one crossing over the New York City area, at 7:52 a.m. EST on October 5th, the receiving station of RCA Communications, Inc., at Riverhead, Long Island, measured the change in frequency of the carrier wave as the satellite approached and then receded, an example of the Doppler effect. From this the orbital velocity was deduced to be 4.92 miles per second.

Several monitoring stations picked up other strong 20-megacycle signals, probably originating from a ground station in the Moscow area, which apparently triggered the telemetering system in the satellite.

The earliest reports of visual sightings were contradictory. Later, apparently reliable optical observations of a bright object were obtained on October 6th and 8th at Mt. Stromlo Observatory, Australia, and at the University of Alaska. On the morning of October 9th, it was seen as a 5th-magnitude object from the University Observatory, Vienna, Austria.

Smithsonian astronomers obtained a preliminary orbit on October 9th, using the digital computer at Massachusetts Institute of Technology. Their calculations, based on a radio observation at Boulder, Colorado, and sightings in Alaska and Australia, gave 370 miles as the average height of the satellite. Later computations gave a perigee distance of 143 miles and an apogee of 583 miles.

Actually, three pieces of "hardware" were moving in closely similar orbits: the satellite itself, the discarded third stage, and the empty nose cone of the rocket. Probably most authenticated visual observations refer to the third stage which, much larger than the 22.8-inch sphere, may well appear brighter. Because of its greater air drag, the third stage should be moving below and *ahead of* the satellite, a seeming paradox prèdicted by celestial mechanics. This fits a report from Hobart, Tasmania, of the passage of a bright body followed by a fainter one.

The first indications of the downward spiraling and eventual destruction of the Russian moonlet may have been reports from the Cavendish Laboratory, Cambridge, England, that radio observations showed a diminished height. At this writing, the lifetime of the satellite cannot be foretold with accuracy.

The first MOONWATCH observation seems to be that by James Plato, at New Haven, Connecticut, on October 10th at 5:23 a.m. EST, confirmed by station leader Robert Brown. The satellite (or more probably the third stage) was photographed on October 9th with the super-Schmidt meteor camera at Newbrook, Alberta, Canada. On October 12th, the Amateur Telescope Makers of Boston timed an early-morning passage of the third stage across the fields of several telescopes, getting a good taped recording.

Observers with MOONWATCH equipment should be especially on the lookout for the fainter true satellite, of probably 5th to 7th magnitude, which was trailing the sunlit third stage by many minutes.

Other satellites, both American and Russian, are expected during the remainder of the International Geophysical Year. The first American launching is to be in December, according to President Eisenhower's statement of October 9th.

NEWS NOTES

SATELLITE WEATHER PICTURES TO BE MADE WITH PHOTOCELLS

Hurricane warnings and other vital weather information could be more comprehensive and accurate if we could obtain views of the earth from artificial satellites. This has already been proposed by Harry Wexler (*Sky and Telescope*, March, 1956, page 208). Last spring he released a picture showing the hypothetical appearance of North America and its cloud formations from a television camera in a satellite 4,000 miles high.

Such a television "station" in space is beyond present technological achievement, but in August's *Scientific Monthly* S. F. Singer, University of Maryland, describes how simple photocells could be used to scan the brightness changes of clouds, continents, and oceans, from a satellite only 200 or 300 miles above the earth's surface.

Repeated transmissions from the satellite photocells to ground stations would permit the building up of weather pictures in which trained meteorologists could recognize cloud formations and track their movements. Although this method would take longer than a television camera to record the picture of an area, weather movements are slow enough so this would not be a handicap.

The resolution required to recognize weather features need not be great – 10 to 100 miles would do. On the basis of Dr. Wexler's original picture, Dr. Singer shows how our continent would look if scanned, from a pole-to-pole orbit 300 miles high, by a single photocell making adjacent sweeps in a nearly north-south direction. The photocell would have a field of view of 800 kilometers at right angles to the satellite's motion.

In such a "photograph," large cloud masses could be recognized, while the same view taken with two photocells mounted in the satellite would show additional details. A four-cell "exposure" would clearly reveal the most important features of the television picture, including cyclones, West Indian hurricanes, and line squalls, with smaller details being moderately visible.

1959 TOTAL ECLIPSE

The next total eclipse of the sun to be visible from the United States will occur two years from now, on October 2, 1959. According to the detailed predictions in *Circular* 78 of the U. S. Naval Observatory, totality may be seen shortly after sunrise in northeastern Massachusetts and southern New Hampshire, in a strip about 38 miles from north to south and about 63 miles from east to west. The duration of totality will be about 56 seconds along the central line, which passes nearly through Fitchburg and Salem, Massachusetts. Boston lies inside the path of totality. In this entire area, however, the sun will be less than two degrees above the horizon.

After leaving the New England coast, the path of totality spans the Atlantic Ocean, crosses North Africa, and ends in the Indian Ocean. The closing partial stages will be visible from a large part of the eastern United States, where the sun will rise already eclipsed.

ONR ASTRONOMY PROGRAM

The Office of Naval Research will continue its program in support of astronomical research during the year June, 1958, to June, 1959. Dr. G. C. McVittie, University of Illinois Observatory, is chairman of its seven-man advisory panel. Applications for support of research in astronomy must be submitted by December 15th. Details can be obtained from the Chief of Naval Research, Department of the Navy, Attn: Code 410, Washington 25, D. C.

DISTANCES OF CLUSTERS

New values for the distances of 16 prominent galactic star clusters are presented by Harold L. Johnson, Lowell Observatory, in the July issue of the *Astrophysical Journal.*

These distances are photometric, being based on photoelectric measurements of cluster stars in ultraviolet, blue, and yellow light. Through comparison of the three brightnesses for each star, he could determine both the amount of dimming by interstellar dust and the intrinsic color (hence absolute magnitude, in the case of a main-sequence star). Dr. Johnson has refined the method to take into account evolutionary changes in the brightnesses of stars of different ages. The distances found in this way have, for the most part, uncertainties between 10 and 20 per cent.

Dr. Johnson has also deduced photometric distances of four stellar associations: I Persei, 520 light-years; II Persei, 1,140; I Orionis, 1,300; and III Cephei, 2,380.

DISTANCES OF CLUSTERS

Name	*Constellation*	*Parsecs*	*Light-years*
Hyades	Taurus	40	130
Coma cluster	Coma Berenices	80	260
Pleiades	Taurus	126	410
Praesepe	Cancer	158	515
Messier 39	Cygnus	250	820
IC 4665	Ophiuchus	330	1,080
Messier 34	Perseus	440	1,440
Messier 25	Sagittarius	550	1,790
Messier 67	Cancer	830	2,710
NGC 2264	Monoceros	870	2,840
Messier 36	Auriga	1,260	4,110
NGC 2362	Canis Major	1,450	4,730
NGC 6530	Sagittarius	1,580	5,150
NGC 2244	Monoceros	1,660	5,410
Messier 11	Scutum	1,740	5,670
Double cluster	Perseus	2,250	7,340

IN THE CURRENT JOURNALS

THE ORIGIN AND IMPLICATIONS OF THE COSMIC RADIATION, by Serge A. Korff, *American Scientist*, September, 1957. "We may also say a word about the astrophysical implications contained in the galactic acceleration picture of cosmic rays. There are two quite different possibilities, first that cosmic rays are in equilibrium today, being produced, accelerated, and absorbed, so that we are measuring a part of a long-term equilibrium process, and the second that cosmic rays are residual from an original catastrophic explosion."

AIR NAVIGATION SINCE WORLD WAR II, by John F. Heard, *Journal of the Royal Astronomical Society of Canada*, August, 1957. "Since the end of the war, I believe few astronomers have had opportunities to keep abreast of the developments in air navigation. These developments have been rather astonishing, both from the point of view of principle and technique, and a review of them should be of interest to astronomers."

WEST VIRGINIA CEREMONY FOR RADIO OBSERVATORY

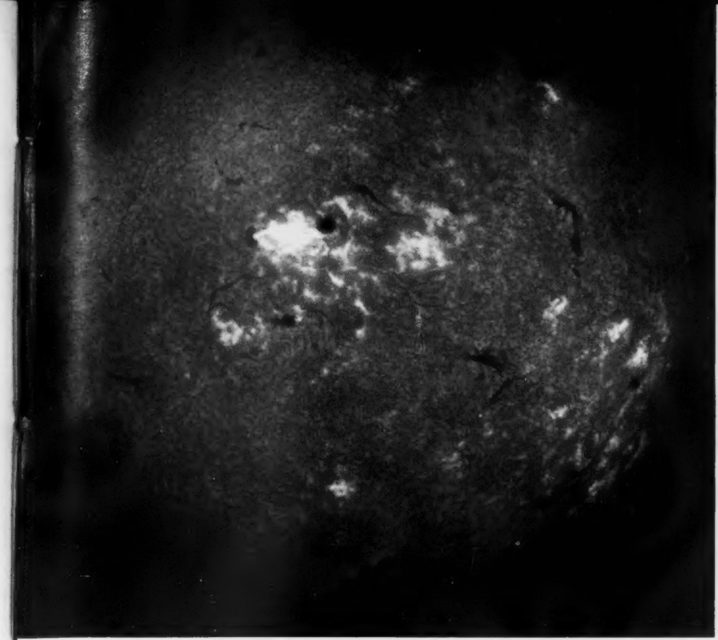
On October 17th at Green Bank, West Virginia, a ground-breaking ceremony was scheduled for the new National Radio Astronomy Observatory. This major research facility is to have a radio telescope 140 feet in diameter, as described on page 398 of the July, 1956, *Sky and Telescope*. The observatory is being sponsored financially by the National Science Foundation, which has made a contract for its establishment and operation with Associated Universities, Inc.

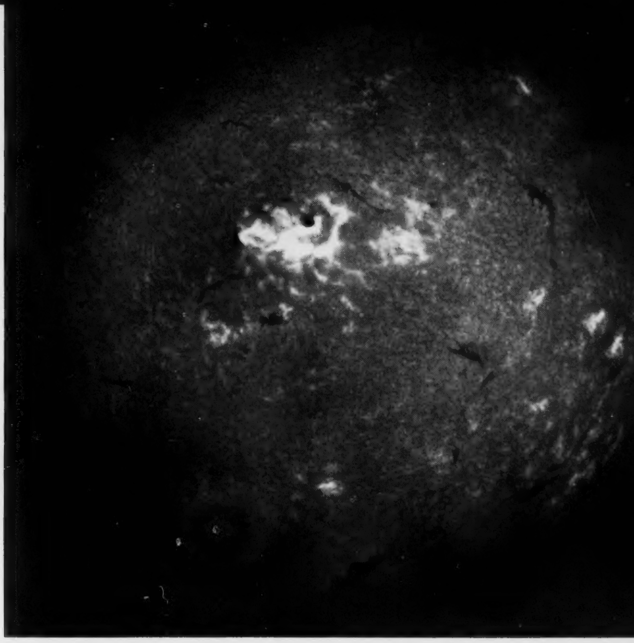
RADIO TEST FOR A LUNAR ATMOSPHERE

A new demonstration, more far-reaching than any before, of the extremely low density of any atmosphere the moon may have is reported in the August *Philosophical Magazine* by B. Elsmore, of the Cavendish Laboratory, Cambridge, England.

On January 24, 1956, the moon occulted the Crab nebula in Taurus, one of the most intense localized radio sources in the sky. This phenomenon was recorded with the Cambridge radio telescope on a wave length of 3.7 meters. As the diameter of the source at this wave length is about five minutes of arc, the observed radio intensity took some 10 minutes to decrease to zero as the moon moved in front of the nebula, and a corresponding increase took place gradually at immersion an hour later.

The total duration of the occultation was observed to be 59.6 minutes, with an uncertainty of ±0.26 minute, as compared with the predicted duration of 59.2 min-



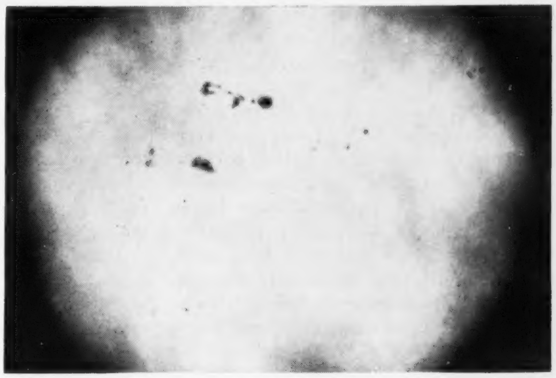


Sudden brilliant outbursts on the sun known as flares are key phenomena in the study of solar-terrestrial relations. These Sacramento Peak Observatory pictures, in hydrogen light, show a strong flare that occurred on September 18th. At 17:37 UT it was of importance 2+ (left), and by 18:38 had grown to importance 3+ (right). There were also sharp bursts of solar radio emission at 18 megacycles. The dark filaments are ordinary hydrogen prominences seen against the sun's disk.

utes. While the excess of 0.4 minute may not be significant, it could be interpreted as due to a refraction of the radio waves by free electrons in a lunar atmosphere. The electron density at the moon's surface required to produce the effect would be about 1,000 per cubic centimeter.

Dr. Elsmore points out that on the sunlit side of the moon whatever atmosphere there is should be completely ionized, all of its atoms broken up into ions and free electrons. Hence he could calculate the total amount of atmosphere necessary to provide an electron density of the above amount. It turns out that any permanent lunar atmosphere must have a density less than 5×10^{-13} that of the earth's air at sea level. This is a maximum value, since the observed amount of refraction of radio waves by the moon is an upper limit.

This radio result extends the work of Audouin Dollfus, who photographed the moon's cusps at the Pic du Midi Observatory and concluded that the lunar atmosphere must be less than 10^{-9} the density of air at sea level (*Sky and Telescope,* December, 1956, page 72).



Compare the sun's disk, as seen here in white light, with the hydrogen pictures above to find the relation of the flare area and the largest group of sunspots visible that day. This photograph was taken through clouds at the U. S. Naval Observatory, Washington, D. C., by Mrs. Winifred S. Cameron.

LONG-ENDURING METEOR TRAINS

According to Charles P. Olivier, retired director of the Flower and Cook Observatory, one meteor out of each 750 leaves behind it a luminous train lasting for more than 10 seconds, as seen with the unaided eye. He has recently published a catalogue of 575 such long-enduring trains, supplementing his two earlier lists of 1,492 similar objects.

Of the 575 trains, observed chiefly between the years 1926 and 1956, six persisted for one hour or longer. In many cases the drift of the train across the sky allowed the determination of upper-air wind velocities, averaging about 200 kilometers per hour. The relatively few determinations of these winds from day and twilight meteor trains give slightly lower values.

Vivid colors are occasionally observed for the nighttime trains, but by day or in twilight the hue is ordinarily smoky or grayish. In recent years it has become increasingly difficult to distinguish between daytime trains and the much commoner vapor trails left by aircraft.

In the same article, Dr. Olivier presents a table of heights and orbital elements for 102 fireballs, as deduced from visual observations. While Baker-Schmidt cameras and radars give far greater accuracy, stations with such equipment are so few that only in rare cases can they secure observations of the most brilliant and interesting fireballs. Visual records by amateurs remain very desirable, especially for objects appearing over the oceans, which otherwise would not be reported.

Dr. Olivier's study appeared in the June, 1957, *Proceedings* of the American Philosophical Society.

NSF RESEARCH GRANTS

Proposals for funds to support professional research in astronomy may now be submitted to the National Science Foundation; if received by the end of November they will be considered at the annual meeting of the foundation's advisory panel.

A booklet giving detailed information on the preparation of proposals may be obtained from Dr. Geoffrey Keller, program director for astronomy, at the National Science Foundation, Washington 25, D. C.

SOUTH-NORTH COMPARISON

There are approximately three times as many large telescopes in the Northern Hemisphere as in the Southern, and 20 times as many professional astronomers in the north as below the equator. This situation, which was even more lopsided 30 years ago, is cited in the *Monthly Notes* of the Astronomical Society of Southern Africa from an article by A. D. Thackeray in the May issue of the South African *Journal of Science.*

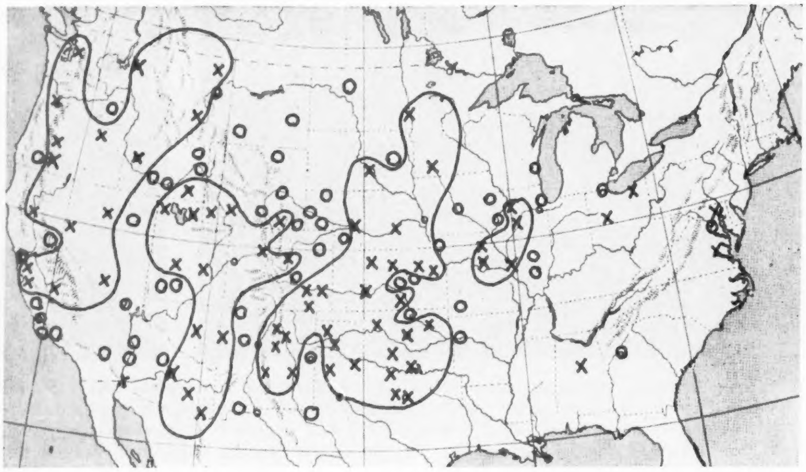
The Great Aurora of September 22-23

JAMES E. MCDONALD, *Institute of Atmospheric Physics, University of Arizona, Tucson*

AN INTENSE and widespread auroral storm began early in the evening of Sunday, September 22, 1957, and lasted until the predawn hours of the following day. At the peak of its activity, near 10 p.m. Mountain standard time, auroral observations were being made from coast to coast and all of the way from the Mexican border up to the Canadian line and possibly still farther north. In this summary all times cited are MST.

The diffuse reddish glow, typical of relatively rare low-latitude aurorae, was seen in Tucson, Arizona, at about 7 p.m. and then disappeared, only to reappear near 10 p.m., the time of nationwide maximum intensity. R. S. Shaw, of Tucson, has provided an excellent report of visual observations from the northern edge of the city, where artificial lights were nearly absent. A coppery red glow, from northwest to almost due east, was visible at about 9:45 p.m. above the Santa Catalina Mountains, some 10 miles away. Suddenly, at about 9:50, within only a few seconds the upper edge of this glow very rapidly ascended to an altitude of over 35 degrees, as estimated from Polaris, and remained there until the display faded near 10 o'clock. Occasional yellowish-white vertical rays emanated from near magnetic north, but apparently did not march laterally as such rays frequently do.

During inquiries to determine whether this display was limited to our Arizona area, I ultimately learned of a source of information of which I had been previously unaware—the informal special reports of aurora observations, labeled by the codeword AURBO, which are encoded at the end of the hourly airways weather reports, disseminated by teletype throughout the country. My discovery of this source of data was unfortunately belated, and on the evening of the 23rd it took a diligent search through two large waste barrels, with the energetic aid of J. C. Killian of the Civil Aeronautics Administration's Tucson office, to retrieve the key teletype sequences containing the auroral data.



In the author's map of the great auroral storm of September 22-23, 1957, crosses mark sightings at 10 p.m. Mountain standard time; circles are stations not reporting aurora. The north-south elongation of the zones of visibility may indicate the influence of the earth's magnetic field.

After filtering out sought-for sequences from bits of lunches and reams of yellow paper, only to discover that I had failed to hunt for the 11 p.m. data, I hesitated to ask Mr. Killian's renewed help in once again dumping and combing through the barrels. My reluctance, however, was quickly removed by his accusation that I seemed not to be showing the scientist's proverbial perseverance in getting the data at all costs, and together we found the missing hour's records in the depths of the well-filled barrels. The complete set of reports has permitted a reasonably full examination of the time development and the geographic coverage of this particular storm, so the scavenging seems now to have been worth while.

At the Sacramento Peak Observatory in New Mexico, Guenther Schwartz photographed the September 22nd aurora, using a Baker super-Schmidt meteor camera, only a portion of its 55-degree field being shown here. This 15-second exposure on Tri-X film was made at 10:49 p.m. Mountain standard time. Until then, trees masked the aurora, low in the northeast. "The arc that was visible was very reddish in color, the rays primarily whitish with a green tinge," Mr. Schwartz noted in his record book. Air Force Cambridge Research Center photograph.

The accompanying map shows the pattern of auroral observations relayed at 10 p.m. MST by Weather Bureau and CAA stations at a total of about 260 points over the country. The teletype data available in the Tucson office includes most stations in the West but only a fraction of the eastern ones. This unevenness happened to be not too serious in the present case, since a very large area of overcast skies lay behind a cold front extending from southern Texas, along the Appalachians, and into New England; only scattered stations in that area could see

the aurora anyway. By contrast, the western states were dominated by the sky-clearing action of the subsidence of air in a large anticyclone centered over Colorado on the evening of the 22nd; thus the West enjoyed a good opportunity for viewing this large auroral storm. The first tele-typed accounts of auroral sightings came at 8 p.m., an hour after the earliest observations in Tucson, reached a maximum of 73 stations reporting aurora at 10 p.m., fell a bit near midnight, recovered slightly at 1 a.m., and ended after 4 a.m. on September 23rd.

Crosses on the map show all stations where aurorae were reported, and circles indicate places for which I found reports of completely clear skies at 10 p.m., but where no notation of aurora was included. Unfortunately the regulations for reporting aurorae at airways stations are such that we cannot conclude that every circle on the chart marks a spot where aurora was positively absent at that time. As part of a further study of this storm, I am now making special inquiries at some 20 selected circled stations. More information from them will help interpret the odd elongation of the zones reporting the 10 o'clock aurorae, an elongation that seems roughly to parallel the magnetic meridians.

Of the 73 stations recording aurorae at 10 p.m., the farthest south was Douglas, Arizona, in latitude about 31° north. Grand Island, Nebraska, holds the distinction of reporting aurorae at every hourly observation from 8 p.m. to the close at 4 a.m.

The daily routine by which this airways data is processed makes it extremely difficult to extract information such as here summarized, if one tries it more than about one day after an auroral storm. This is because these auroral reports are not entered on the easily processed punch cards which the Weather Bureau uses for standard data. Instead, they are entered by hand on a certain form (WBAN 10-B) that is ultimately filed in the archives by station rather than by hour, thus precluding easy synoptic analysis. Happily, however, the data are in convenient form if secured from any airways station before the original teletype sheets are thrown away (a daily disposal problem at such stations).

To my knowledge, no systematic study of these hourly airways reports of aurorae is now being carried out. The IGY auroral program being conducted by D. S. Kimball and C. W. Gartlein with Weather Bureau co-operation is, for example, drawing on only some 85 principal Weather Bureau stations, whereas there are about 500 airways stations in the country. Despite the less carefully controlled conditions of observation and recording in the case of the airways reports, I do believe that these provide interesting opportunities for study by amateur astronomers who live where teletype stations are maintained. The current peak of solar activity makes this year and the next especially good for such efforts.

LETTERS

Sir:

Page 333 of the May, 1957, *Sky and Telescope* reported the work of John S. Rinehart on the ablation or wastage of meteoritic bodies during their flight through the earth's atmosphere. My studies of this problem are presented in the book *Foundations of Meteoritics*, Moscow, 1955, and in the German journal *Chemie der Erde, 18,* 56-88, 1956.

From the properties of individual specimens of the Sikhote-Alin and other meteoritic showers, the following rule was established: If a specimen shows the earmarks of stable orientation during flight (roughly conical shape, flow marks on the front which have about 1/10 the diameter of the meteorite), then the rear surface has one of two kinds of structure—either with fully developed but much larger flow marks, or having sharp-edged irregularities.

The significance of these two types comes from the fact that there is little or no ablation at the rear surface of a meteorite falling with stable orientation. Suppose that the original meteoritic body broke up during its flight, and that a fragment preserved constant orientation during its remaining fall. Then its rear surface, if part of the original exterior, would show the large flow marks of the original body. On the other hand, if the rear face of the fragment were a surface of fracture, it would show the sharp irregularities of the fracture.

This reasoning may be applied to the photographs of the Cabin Creek meteorite that were published with the *Sky and Telescope* account of Dr. Rinehart's work. The approximately conical shape and the flow marks on its front show that flight was stable. But the back bears typical flow marks that are much larger than 1/10 the specimen's size. Hence we conclude that the Cabin Creek meteorite is only a fragment of an original body two or three times larger, perhaps 90 inches in diameter, to judge from the size of the rear flow marks.

Also, this rear surface formed part of the exterior of the original body. Therefore this specimen gives an excellent opportunity for studying the change in chemical composition with depth below the original surface. Such analyses give information on the influence of cosmic radiation on the formation of isotopes, including helium of mass three, in the meteorite.

E. L. KRINOV
Committee on Meteorites
U. S. S. R. Academy of Sciences
Moscow, U. S. S. R.

Sir:

While searching for Comet Mrkos on August 4th, we observed a phenomenon apparently related to the green flash. The western horizon was cloudless but hazy, and the setting sun deep red. We turned a mounted 3-inch 21x terrestrial refractor on the sun as it neared the horizon. Owing to layering of the air, the sun's limb appeared slightly notched; as the sun set, pairs of corresponding notches moved upward across the disk, pinching off small "bubbles" from the top.

Each bubble gradually turned orange, yellow, and finally pale green before it faded out, the whole process taking up to three seconds. By comparison with the telescopic disks of Venus and Jupiter, we estimated that the bubbles were about half a minute of arc in diameter. The upper limb of the sun also showed a yellow-green fringe, considerably narrower than the bubbles. Neither bubbles nor fringe could be seen in hand-held 7-power binoculars.

The green color seemed real; the observations of Venus and Jupiter showed it was not due to chromatic aberration in the telescope, and the gradual nature of the color and brightness changes rules out an explanation by eye fatigue.

On the following night the sky was clearer at sunset, the sun was brighter, and nothing unusual was observed.

W. E. HOWARD, III,
and A. T. YOUNG
Harvard College Observatory
Cambridge 38, Mass.

Sir:

On page 494 of the August issue, Edgar Everhart describes sidereal drives for telescopes, and proposes the accurate gear train 1 r.p.m. × 20/66 × 14/56 × 34/37 × 1/100. The identical ratio can be obtained from the train 1 r.p.m. × 5/55 × 17/37 × 1/60, which is easier to construct because it requires fewer gears. Both trains are available in standard Boston gears. My train has a 5-tooth pinion and 20-pitch change gears.

ROBERT M. AYERS
1374 S. Branch Pkwy.
Springfield, Mass.

Sir:

The caption under the photograph of Jupiter on page 397 of the June issue contains an error. The prominent feature at the upper left is a disturbance in the south tropical zone, and not the red spot hollow. Mr. Botham's photograph on March 8, 1956, was taken when the longitude of the central meridian was 224° (System II). On that date the following end of the dusky disturbance was at longitude 215°, while the center of the red spot hollow was at 301°. Hence the latter feature was too near the following limb to be seen on the photograph.

ELMER J. REESE
R.D. 2, Box 396
Uniontown, Pa.

Amateur Astronomers

Kansas City Convention Marks League's First Decade

ROLL CALL at the opening session of the general convention of the Astronomical League, held at the University of Kansas City, on August 31-September 2, revealed a representation of 42 per cent (more than 50 societies) of the league membership. The 269 delegates who registered came from all parts of the country, from places as widely separated as New England and California, Florida and Oregon, Texas and Wisconsin.

The convention marked the 10th year of the league as a formal organization, although it had its roots in the first convention of amateur astronomers at the New York World's Fair in 1939. In her address as retiring president, Grace C. Scholz recalled a map of the United States displayed at the Philadelphia convention in 1947, when the league was first permanently organized. The map had 72 pins marking all known astronomy clubs at that time. The number of societies in the country is now over 200.

In the past decade the Astronomical League has grown in membership from 30 local organizations to better than 130. Starting with four regions across the northern part of the country, the league now has nine, and each year the general convention is held in a different region.

Miss Scholz announced that the 1958 gathering of the league will be held over the 4th of July weekend, at Cornell University, Ithaca, New York, in the Northeast Region. Although the site for the 1959 convention has not been finally selected, an invitation has been received from the Mountain Astronomical Research Society Region to meet in Denver for a joint conclave with the Western Amateur Astronomers.

The league's two regular publications continue to grow in popularity. The monthly bulletin is edited by Mrs. Jane Gann, of the Columbus Astronomical Society, and will henceforth be called *Reflector,* this being the winning name in the recent contest to rename the bulletin. The *Junior Astronomer* is published in Washington, D. C., by Benjamin Adelman. At Kansas City, a special arrangement was announced whereby, with the support of Norman Edmund, *Reflector* will be sent directly to all individual members of league societies. This is an important milestone in the growth of what Miss Scholz called "our most important internal activity."

In 1952, the league became affiliated with the American Association for the Advancement of Science, and on several occasions has held sessions and displayed exhibit material at AAAS meetings.

Other important activities include the league's book service, at present conducted by Margaret Kobs, of Portland, Oregon, and the support of two affiliated organizations, the American Association of Variable Star Observers and the Association of Lunar and Planetary Observers. In 1951 the first presentation of the Astronomical League award was made to Albert Ingalls, of telescope making fame, and since then a number of distinguished amateur and professional astronomers have received the award; none was made this year.

Miss Scholz told the meeting that the MOONWATCH satellite-observing program provides an unprecedented opportunity for the amateur. About half of the more than 90 teams now set up in the United States have been established in league societies.

She proposed that the league secure funds for developing a library of tape and slide lectures, which would be available to member societies on loan. A first attempt at this program indicates that considerable editing of the tape is required, and that there must be careful co-ordination between the speaker's words and the lantern slides that would be a part of each lecture. The league officers are also seeking the co-operation of the National Science Foundation and the American Astronomical Society in procuring astronomers for lectures at local meetings and for workshops at colleges.

Concluding her address, Miss Scholz pointed out that, although funds for expansion are always important, the present greatest need of the league is for manpower—for leaders who are willing to accept responsibility and who will carry through on projects of benefit to local societies and amateur astronomy in general.

Russell C. Maag, of the Central Missouri Amateur Astronomers, was elected president of the league to succeed Miss Scholz, his term of office beginning at Kansas City.

The exhibits at general conventions continue to grow in importance, and the exhibit area forms a place where discussions between sessions become detailed and lengthy. The Kansas City society prepared a special display of international astronomy from many parts of the world, the material being gathered from societies in Europe, South America, South Africa, and Asia.

There were elaborate displays from several of the manufacturers who are supporting members of the Astronomical League; in several cases their chief officers personally attended the convention to demonstrate their instruments and to learn the needs of amateur observers. The Kansas City program listed 10 supporting members: Coast Instrument, Inc., Criterion Manufacturing Co., E and W Optical Co., Edmund Scientific Co., J. W. Fecker, Inc., S. E. Laszlo, Sky Publishing Corp., Skyscope Co., Spitz Laboratories, Inc., and United Scientific Co.

On Saturday afternoon, there was a satellite-observing program, with five invited speakers, including Col. Owen F. Clarke, U. S. Air Force liaison officer for MOONWATCH, who described the problems of flying airplanes to simulate satellites. Later that day, the delegates toured the Linda Hall science library, under the guidance of its director, Dr. Joseph Shipman. The library regularly subscribes to 7,000 periodicals in science and industry. That evening a star party and observing technique session was scheduled, but clouds covered the moon just 20 minutes before the predicted occultation of Saturn, so that event could not be observed by the delegates.

Sunday's schedule included a junior session and a talk on "Mathematics and As-

Members and guests at the general convention of the Astronomical League

President Grace C. Scholz opening the Kansas City convention of the Astronomical League. Left to right are Gene L. Tandy, general chairman, Dr. Richard M. Drake, chancellor of the University of Kansas City, Mrs. Wilma Cherup, executive secretary, Miss Scholz, Dr. William C. Doyle, S. J., Rockhurst College, and Fred Hartman, president of the Astronomy Club of Kansas City.

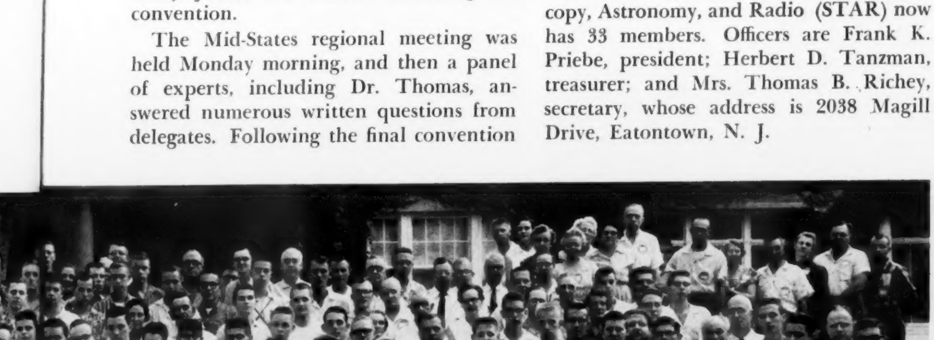
tronomy" by Dr. William C. Doyle, S. J., of nearby Rockhurst College. The convention banquet was held there Sunday evening, with the principal speaker Dr. Richard N. Thomas, of the National Bureau of Standards, Boulder, Colorado. After describing briefly the current problems of the sun's chromosphere, Dr. Thomas appealed to the young people in his audience to take up with him their problems of how to follow astronomy as a career. As a result, later that evening he held a long informal discussion with the many junior astronomers attending the convention.

The Mid-States regional meeting was held Monday morning, and then a panel of experts, including Dr. Thomas, answered numerous written questions from delegates. Following the final convention session, the 10th anniversary meeting of the Association of Lunar and Planetary Observers was called to order at 11 a.m. The society's director, Walter Haas, was chairman for a lively program of papers concerning the moon, Comet Arend-Roland, Mercury, Venus, Jupiter, and Mars. The afternoon program of the ALPO brought the Kansas City convention to a close.

C. A. F.

EATONTOWN, NEW JERSEY

The recently organized Society of Telescopy, Astronomy, and Radio (STAR) now has 33 members. Officers are Frank K. Priebe, president; Herbert D. Tanzman, treasurer; and Mrs. Thomas B. Richey, secretary, whose address is 2038 Magill Drive, Eatontown, N. J.



ical League, University of Kansas City, August 31-September 2, 1957.

THIS MONTH'S MEETINGS

Cambridge, Mass.: Amateur Telescope Makers of Boston, 8 p.m., Harvard Observatory. Nov. 14, Dr. Gerald S. Hawkins, Harvard Observatory, "Comets."

Detroit, Mich.: Detroit Astronomical Society, 2:30 p.m., State Hall, Wayne University. Nov. 10, Dr. Helen W. Dodson, University of Michigan Observatory, "The Solar Program of the International Geophysical Year."

Madison, Wisc.: Madison Astronomical Society, 8 p.m., Washburn Observatory. Nov. 13, Dr. V. E. Suomi, "The IGY and the Space Satellite."

New York, N. Y.: Amateur Astronomers Association, 8 p.m., American Museum of Natural History. Nov. 6, Dr. Ernest G. Reuning, University of Pennsylvania, "An Astronomer Looks at Space Travel."

Washington, D. C.: National Capital Astronomers, 8:15 p.m., Commerce Department auditorium. Nov. 2, Dr. S. Fred Singer, University of Maryland, "Meteors."

NEW YORK JUNIORS

Now entering its 29th season, the Junior Astronomy Club of New York is offering five astronomy classes, in addition to its regular lecture series. The courses cover elementary and intermediate astronomy, and also mathematics and electronics as applied to astronomy.

Students in the electronics course hope to construct such instruments as a photometer, an interferometer, and a photoelectric clock drive devised by Stephen E. Strom, club president. The clock drive would operate a telescope automatically.

Membership information may be obtained from Mr. Strom, 1950 Andrews Ave., Bronx 53, N. Y.

PATERSON, NEW JERSEY

The North Jersey Astronomical Society, now in its third year, has a membership of eight adults and 10 juniors. Most of the members own their own telescopes, and the club has made a 6-inch reflector.

In addition to holding public star parties at Paterson State Teachers College and other sites, the society is currently setting up a MOONWATCH station at Eastside high school, under the supervision of R. DelVecchio. Visual aurora observations during the International Geophysical Year are being undertaken.

Officers are Wilbert M. Diggles, president; Eleonore Kraus, treasurer; and Donald Trombino, secretary. Further information may be had from Mr. Trombino, 4-4D Alabama Ave., Paterson 3, N. J.

SANTA ANA, CALIFORNIA

The permanent meeting place for the Orange County Amateur Astronomers is now room U12 of Santa Ana College. The club meets monthly at 7:30 p.m. on the first Friday, according to the secretary, Glenn H. Shaw, 2061 Halladay, Santa Ana, Calif.

The Most Massive Stars Known

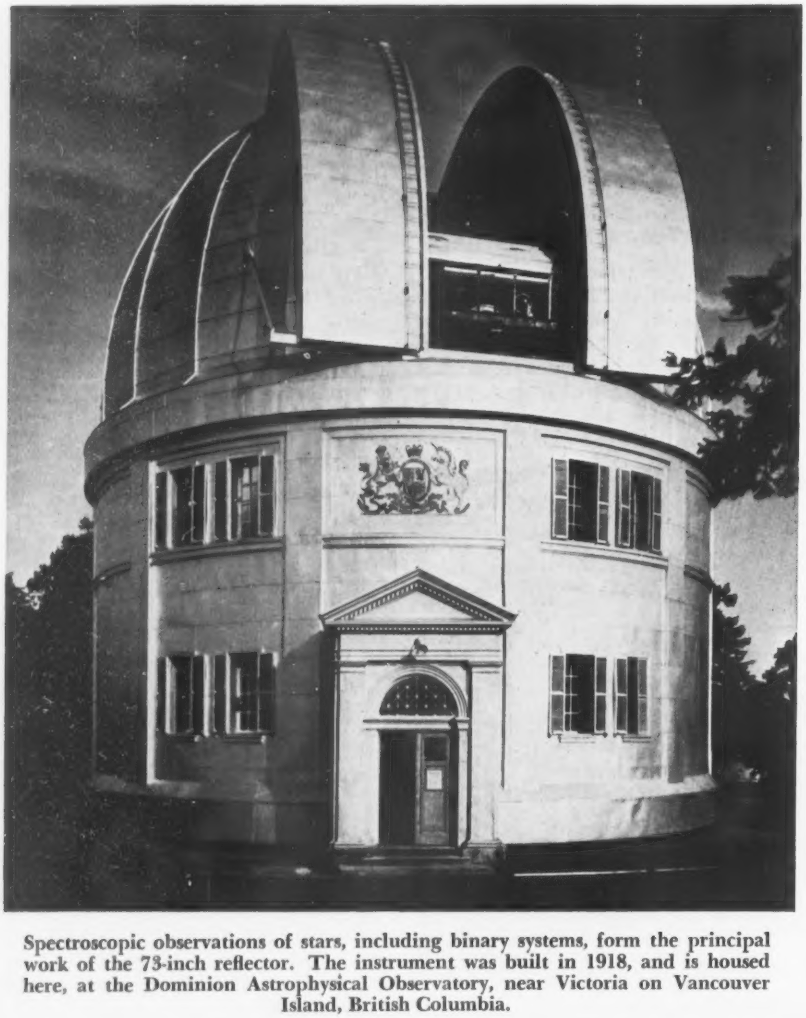
OTTO STRUVE, *Leuschner Observatory, University of California*

A VITAL PART of modern astrophysics had its beginning about 150 years ago, when it was realized that many visual double stars were not mere chance pairs but actual binary systems, often with conspicuous orbital motion. This motion was the visible effect of the gravitational attraction of one star upon the other. Since that time, astronomers have succeeded in determining the masses of the component stars of many binaries.

Data on star masses is fundamental to our newly gained understanding of stellar structure and stellar evolution, yet, even today, the only sure basis of this data is the orbital motion of the visual and spectroscopic binaries. We cannot measure the mass of an isolated star – except the sun, which has planetary companions. We are forced to assume, as a first approximation, that the masses of single stars resemble those of double star components having similar luminosities, diameters, and surface temperatures.

Popular writers usually avoid explaining how the masses of double stars are computed because the problem involves a fair amount of algebra if all kinds of binaries are included in the discussion. But the basic ideas are quite simple, and the masses of the heaviest known stars can be found from elementary considerations.

Large stellar masses are of particular interest. What is the heaviest star or pair of stars now known? Is there a physical limit to the amount of matter a star can accumulate? And what are the properties of the heaviest stars?



Spectroscopic observations of stars, including binary systems, form the principal work of the 73-inch reflector. The instrument was built in 1918, and is housed here, at the Dominion Astrophysical Observatory, near Victoria on Vancouver Island, British Columbia.

We choose for our example Plaskett's star, a very massive binary system just visible to the naked eye, located in the constellation of Monoceros about midway between Procyon and Betelgeuse. Also known as HD 47129, this object is of visual magnitude 6.1, and its spectrum is of type *O*8. In 1922, the Canadian astronomer J. S. Plaskett discovered it to be a spectroscopic binary, from spectrograms taken with the 73-inch reflector of the Dominion Astrophysical Observatory at Victoria, British Columbia. The period of orbital motion is 14.4 days.

In Fig. 1 are plotted observations of the radial velocities of the two stars that constitute this system. The velocity curve of the primary star – the one with the stronger absorption lines – is represented by the dots. The symmetry of the curve shows that the orbit of this star relative to the other is very nearly circular.

What we measure on the spectrograms are the Doppler displacements of the absorption lines at different times (see Fig. 3). This gives us the star's radial velocity, that is, the component of the true velocity that lies along the line of sight, at each phase. At phase 0 day, the primary star is approaching us with a velocity of 190 kilometers per second, and at phase 7.2 days it is receding at 240 kilometers per second.

A part of the velocity is due to the motion of the system as a whole relative to the sun. Were this motion zero, the circular orbit of the primary star around the center of gravity would produce equal values for the maximum observed velocities of recession and approach. The fact that these two velocities are unequal shows that this is not the case – the center of gravity is receding from us with a constant velocity of $\frac{1}{2}(240 - 190) = 25$ kilometers per second. The dashed line in Fig. 1 indicates this motion of the center of gravity.

Thus, with respect to the center of gravity, the primary star is moving 190 + 25, or 215 kilometers per second when its velocity of approach is greatest, and 240 – 25, or 215 kilometers per second at maximum velocity of recession. This would be the orbital velocity of the primary star with respect to the center of gravity, provided the orbital plane were in the line of sight, that is, if the orbit were presented to us edgewise.

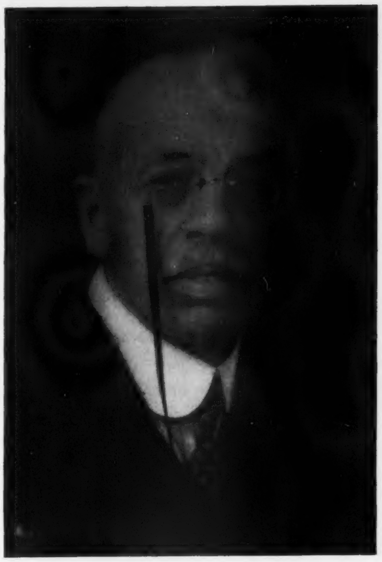
But since HD 47129 is not an eclipsing

variable star, we infer that the orbit is not edge-on; there appear to be no rhythmic light variations caused by one star eclipsing the other at each revolution. The true orbital velocity must be larger than 215 kilometers per second, being diminished by foreshortening. Exactly how much larger is not known, but we shall probably not be far from the truth in assuming that the real, unforeshortened velocity is about 250 kilometers per second. This value corresponds to a tilt of the orbit plane of 30 degrees to the line of sight.

Assuming, then, that the primary star of HD 47129 is moving in a circular orbit at 250 kilometers per second, what can we deduce concerning the masses in this system? We shall begin by applying Newton's first and second laws of motion. The first law is that a moving body not subjected to any external force will continue to move in the same direction and with unchanged velocity. Newton's second law states that a body moving with changing velocity or direction is being subjected to a force that is equal to the product of the body's mass and its acceleration (the change in amount and direction of velocity). This law is expressed in the well-known formula, $f = ma$.

Suppose, in Fig. 2, that the primary star is in position A. Its orbital velocity of 250 kilometers per second is tangential to the circular orbit, as shown by the arrow. If no force were acting on the star, it would arrive at D, the end of the arrow, after a lapse of one second. In reality the star arrives at position B. Its speed is still 250 kilometers per second, but the direction of the next velocity arrow, starting from B, is not the same as that of the initial velocity at A. The star has experienced a central force that has caused it to "fall," in the course of one second, from D to B.

This distance of fall in one second is numerically just half of the acceleration. It is like the case of a stone falling from rest to the surface of the earth. Its acceleration or increase in velocity is 32 feet per second each second; and it falls 16



Plaskett's star is named after the Canadian astronomer J. S. Plaskett, director of the Dominion Astrophysical Observatory from 1917 to 1935.

feet in the first second. If the stone has an initial horizontal velocity, the result is still the same, its fall toward the earth in the first second is still 16 feet, or half the acceleration.

In Fig. 2, one leg of the triangle CAD is the radius of the orbit, the distance between the center of gravity and the star. The circumference of the orbit is the orbital velocity (250 kilometers per second) times the period (1.24×10^6 seconds), or 3.1×10^8 kilometers; the radius is thus about 5×10^7 kilometers. The other leg of the triangle, AD, is the star's motion in one second, or 250 kilometers. Finally, the hypotenuse is the orbital radius, 5×10^7 kilometers, plus the distance of the fall, which we shall call x.

From the Pythagorean theorem for a right-angle triangle,

$$(5 \times 10^7 + x)^2 = (250)^2 + (5 \times 10^7)^2.$$

Because x^2 is relatively very small we can neglect it, and a little arithmetic shows that $x = 6.25 \times 10^{-4}$ kilometers, or 62.5 centimeters. Doubling this distance of fall gives for the acceleration 125 centimeters per second each second. Newton's second law can therefore be written $f = 125m$, where f and m are in dynes and grams, respectively, the units in the centimeter-gram-second system.

In order to solve for the mass, however, we need Newton's law of universal gravitation. This states that the force in dynes between any two bodies is equal to 7×10^{-8} (the gravitational constant) times the product of their masses in grams, divided by the square of their distance apart in centimeters.

But we know only the primary star's distance from the center of gravity, which can be called a; for the other star the corresponding distance is a', and the stars' total separation is $a + a'$. From Fig. 1 we may infer, despite the large scatter in the measurements, that the secondary's velocity curve has about the same range as that of the primary star. Therefore the radius of the secondary orbit should be about the same as the primary's, and a' should also be about 5×10^7 kilometers. The sum of these distances, $a + a'$, is thus twice this value, or 10^{13} centimeters.

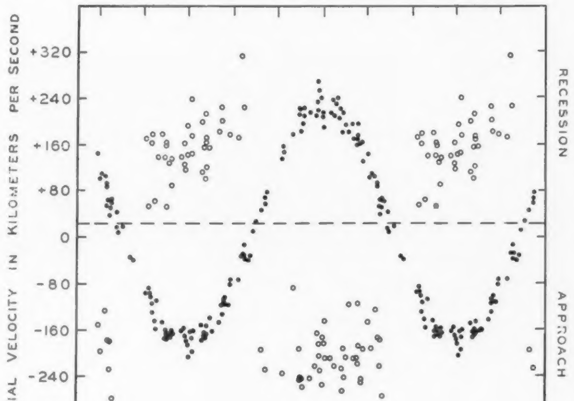
Now we are ready to equate the force, which acts on the primary star according to the law of gravitation, with the force expressed by the second law of motion, making the assumption that gravitation alone holds the two stars in their orbits:

$$(7 \times 10^{-8})mm'/(a + a')^2 = 125m.$$

The factor m can be cancelled from both sides of this equation, while $(a + a')^2$ is 10^{26}. The equation can be solved for m', the mass of the secondary star, which comes out 1.8×10^{35} grams.

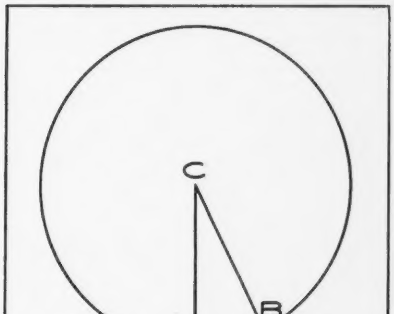
Since the mass of the sun is 2×10^{33} grams, the secondary component of Plaskett's binary is about 90 times as great. The primary star should also be about 90 solar masses, because we believe that the center of gravity is about midway between the stars. The total mass of this double star is thus some 180 suns!

It is important to review our assumptions. We supposed that the force deduced from the observed acceleration is purely gravitational, but in principle it is



Left: Fig. 1. K. D. Abhyankar, of Leuschner Observatory, has plotted radial velocity observations of HD 47129, using dots for the primary star, circles for the secondary, from spectrograms taken at Victoria, McDonald, and Lick Observatories.

Right: Fig. 2. In this diagram, where the circle represents the orbit of the primary star about the center of gravity, x indicates the distance of fall in one second.



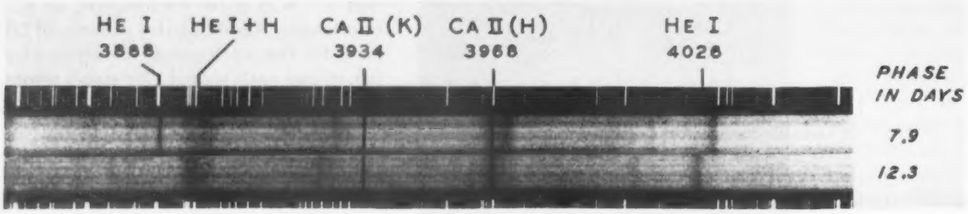


Fig. 3. In spectra of HD 47129, the diffuse dark lines of the primary star are shifted by the Doppler effect. Sharp dark lines are of interstellar origin, hence undisplaced by orbital motion.

the sum of physical forces of all possible types. Yet we know that in the solar system gravitation by itself suffices to explain the motions of the planets and satellites — magnetic, electrical, and other forces are negligible. If they were of consequence in a double star system, they would be detectable from their spectroscopic effects.

Another assumption involved the tilt of the orbital plane to the line of sight. It is pretty certain that we have not underestimated the true orbital velocity of the primary component. As has been mentioned, if the orbital plane were close to the line of sight, Plaskett's star would be an eclipsing binary, but no eclipses have been observed. If the orbit plane is tilted to the line of sight by more than the 30 degrees we selected, then the true orbital velocity would be even greater than 250 kilometers per second, and the resulting masses would be larger. Therefore, this assumption yields minimum values for the masses.

Our third assumption was that the two components have equal masses. This rests upon the rough estimate from Fig. 1 that the range in radial velocity is the same for both components. If, as seems likely, the range of the secondary is somewhat smaller than the primary's, then the secondary is the more massive star.

These stellar masses, of the order of 90 times the sun's, are the largest definitely known at the present time. We may therefore conjecture that the upper limit of possible star masses is about 100 times the sun, or 2×10^{35} grams. It was suggested many years ago by Sir Arthur Eddington that the radiation pressure inside a star of this mass is high enough to offset the internal gravitation that holds the star together — if there were any star of larger mass, radiation pressure would blow it apart.

It is therefore of interest that Plaskett's star appears highly unstable. One or both components are shedding gas into interstellar space, and in many respects behave like a slowly exploding star of the P Cygni or Wolf-Rayet type.

Fig. 3 shows a portion of the spectrum of Plaskett's star at two phases, 7.9 and 12.3 days. The large Doppler shift of the primary component can easily be seen for the helium line at 4026 angstroms. Features arising from the secondary star can hardly be discerned in this spectral region, the ultraviolet, but are easily seen in the red. The very sharp dark lines marked K and H are of interstellar origin; they result from the absorption of light by ionized calcium atoms situated between us and the star.

Of special importance is the strong line of helium at 3888 angstroms, discovered by J. Sahade. This absorption line is present only at phases close to 7.9 days, and then gives a velocity of approach of about 700 kilometers per second. At that time there is something resembling a rapidly approaching jet of helium gas which passes between us and the primary star. It is believed that this jet originates from the secondary component, and diffuses toward all sides to form ultimately a vast expanding shell of tenuous nebulous matter. The primary component also ejects gas, especially hydrogen, but fairly uniformly in all directions.

Other evidence of the instability of Plaskett's star is provided by some of the absorption and emission lines, which suffer irregular changes from cycle to cycle. It is almost certain that similar variations will be found in the brightness of this system. Because of its instability, the star should be observed photoelectrically. In many respects, Plaskett's star is among the most remarkable known, and it promises us a rewarding insight into the problems of very massive stars.

Double Star Studies in Indonesia

At the Bosscha Observatory, near Bandung, Java, photographic observations of double stars form the main program of the 23½-inch refractor. At this nearly equatorial station in Indonesia, it is possible to reach practically all of both the northern and southern skies under very favorable atmospheric conditions.

In his report for the years 1955 and 1956, Director G. B. van Albada tells of special studies of several well-known double stars, including Sirius, Antares, Albireo, and Alpha Centauri. He also reports on the photometry of galactic clusters and observations of Mars in three colors during its 1956 opposition.

In a recent paper concerning photographic observation of binary systems with very large magnitude differences, Dr. van Albada describes the special techniques he has developed to obtain measurable photographs of such difficult pairs as Sirius, with results like that pictured here. The companion is seen above and to the left of the overexposed central image of Sirius. From the astrometric viewpoint, the faint diffraction images on either side of the central one are especially important.

It is standard procedure in double star photography, if the primary star is several magnitudes brighter than the secondary, to produce such fainter images by means of a coarse wire diffraction grating placed in front of the telescope objective. These images are actually spectra of the first order, second order, and so forth. Because one pair of them are of about the same size and density as the image of the companion, the latter's position with reference to them may be measured much more accurately than with respect to the overexposed central image of the primary.

Difficulties arise with this method, however, if the companion is very much fainter than its primary, as in the case of Sirius. Dr. van Albada has found that a grating of only five or six parallel wires, widely but *unequally* spaced, produces the desired result. The spiked appearance of the central image is caused by a hexagonal diaphragm in front of the objective, which produces a strong diffraction of light but reduces the intensity of the image in the spaces between the spikes. The diaphragm is oriented so the image of the companion falls in one of the clear spaces.

The Bosscha Observatory report discusses Albireo (Beta Cygni) as a triple system. Visually, this famous double star has a separation of about 35 seconds of arc. But measurements of photographs in blue and yellow light give positions differing by 0.14 second for the brighter component, which is known to have a composite spectrum. Analysis of all available observations suggests strongly that the yellower component of the unresolved pair is moving in an elliptical orbit around its blue neighbor.

In this recent photograph of Sirius taken with the 23½-inch refractor, the famous white dwarf companion appears above and to the left of the overexposed image of the primary star, which is flanked by diffraction images that can be measured for position. The enlargement from the original negative is about 13 times. From Bosscha Observatory "Contributions" No. 3.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

THE LUNAR ECLIPSE OF NOVEMBER 7TH

THE last of the four eclipses of 1957 will be a total eclipse of the moon on the morning of Thursday, November 7th, whose opening stages will be visible in the western parts of the United States and Canada. For amateurs living east of the Mississippi River, generally speaking, the moon will have set before the eclipse commences. At most places along the Pacific Coast, however, our satellite will be totally eclipsed by the time of moonset.

The timetable that follows has been adapted from the *American Ephemeris and Nautical Almanac;* all times are a.m.

	CST	MST	PST
Moon enters penumbra	5:30	4:30	3:30
Moon enters umbra	6:43	5:43	4:43
Total eclipse begins	8:12	7:12	6:12
Middle of eclipse	8:27	7:27	6:27
Total eclipse ends	8:42	7:42	6:42
Moon leaves umbra	10:10	9:10	8:10
Moon leaves penumbra	11:23	10:23	9:23

As seen from St. Louis, Missouri, the moon will set 10 minutes before umbral eclipse begins; at Minneapolis, Minnesota, moonset comes 16 minutes after the umbral shadow starts to take its first "bite" out of the moon. Only very limited observations can be planned for such points. But farther west, more and more of the eclipse may be seen. At Denver, Colorado, the moon sets 35 minutes before the commencement of totality, and at Tucson, Arizona, 24 minutes before.

West Coast watchers will be the most favored of any in the United States, particularly in more northerly latitudes, where moonset will be delayed because of the north declination (+16°) of the moon. At Pasadena, California, eight minutes of total eclipse may be observed before the moon descends below the western horizon. For Berkeley, California, moonset comes at 6:45 a.m., Pacific standard time, three minutes after the end of totality. At Portland, Oregon, the geometrical conditions are even better, as 20 minutes may be seen of the partial stage following totality.

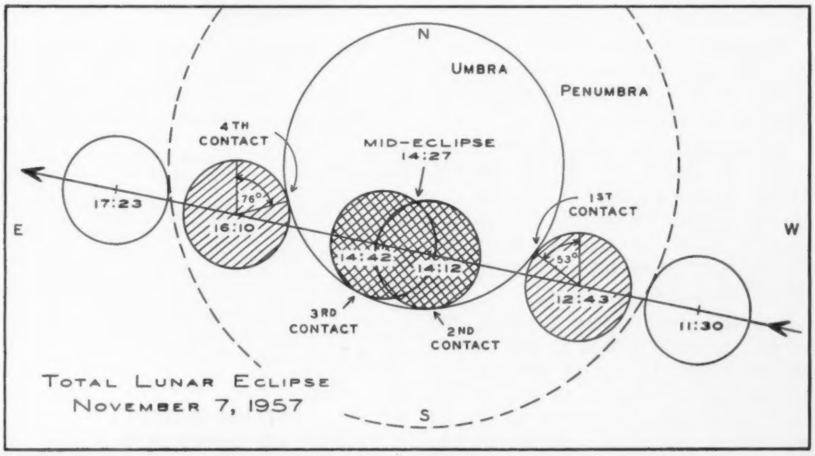
For early-rising amateurs who wish to make visual or photographic observations of the phenomenon, there are many practical suggestions in previous issues of *Sky and Telescope*. Consult page 43 of the November, 1956, number for detailed information on emulsions, lens speeds, and exposure times for filming the eclipse. Page 38 of that same issue lists some projects for visual observers. Among the suggestions made are descriptions of colors on the eclipsed moon, notes on the visibility of craters and seas inside the umbral shadow, and careful records of the times when individual craters enter or leave the umbra.

Even with the unaided eye, a lunar eclipse is an interesting phenomenon to watch. In some places, the eclipsed moon and the sun may be seen above the horizon simultaneously, a seeming paradox explained by atmospheric refraction, which apparently raises both bodies. Binoculars are worth using, and refractors of 2- to 4-inch aperture are well suited for visual observing, as are small reflectors.

The next lunar eclipse will be the partial one of May 3, 1958; like this year's event, it will be visible for United States observers only from the western states.

"THE PHOTOELECTRIC PHOTOMETER"

A wide, inviting field of observational work is open to the advanced amateur who builds a photoelectric photometer and uses it on his telescope for brightness measurements of variable stars. The basic requirements are some practical acquaintance with electronics, a well-mounted telescope of moderate size with a good drive, and a certain amount of astronomical experience. For several years the American



Events on this chart of the moon's path are labeled in Universal time.

Association of Variable Star Observers has had a committee under the chairmanship of Lewis J. Boss to encourage photoelectric work.

This committee has published a small mimeographed manual, *The Photoelectric Photometer,* which contains instructions and circuit diagrams for the construction of a simple photometer and amplifier. There are brief directions for its operation and for the reduction of measurements made with it, based on the successful amateur work of J. J. Ruiz, Dannemora, New York. This manual is available at $2.00 per copy from Mr. Boss, 2111 28th Ave., San Francisco 16, Calif.

SEEING PLANETS BY DAY

Several years ago I planned to observe all of the bright planets by day. Mercury, Venus, Mars, and Jupiter were so seen, but I was not successful with Saturn until August 16th of this year. Using 6 x 30 binoculars, I spotted this planet in a clear sky six minutes before sunset. Since the predicted magnitude of Saturn on this date was +0.7, this means that bright stars like Sirius and Canopus should not be too difficult to see in full daylight.

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SUNSPOT NUMBERS

These are observed mean relative sunspot numbers from Zurich Observatory and its stations in Locarno and Arosa.

August 1, 150; **2,** 148; **3,** 178; **4,** 166; **5,** 147; **6,** 162; **7,** 167; **8,** 141; **9,** 121; **10,** 88; **11,** 95; **12,** 118; **13,** 120; **14,** 135; **15,** 170; **16,** 198; **17,** 189; **18,** 197; **19,** 185; **20,** 170; **21,** 144; **22,** 147; **23,** 114; **24,** 104; **25,** 138; **26,** 164; **27,** 182; **28,** 222; **29,** 244; **30,** 255; **31,** 282. Mean for August: 162.6.

September 1, 257; **2,** 230; **3,** 201; **4,** 166; **5,** 184; **6,** 160; **7,** 137; **8,** 175; **9,** 250; **10,** 265; **11,** 255; **12,** 264; **13,** 260; **14,** 263; **15,** 265; **16,** 283; **17,** 258; **18,** 295; **19,** 317; **20,** 294; **21,** 334; **22,** 302; **23,** 268; **24,** 239; **25,** 234; **26,** 220; **27,** 227; **28,** 249; **29,** 249; **30,** 229. Mean for September, 244.3.

The following American sunspot numbers for July and August were derived by Dr. Sarah J. Hill from AAVSO Solar Division observations:

July 1, 181; **2,** 166; **3,** 198; **4,** 199; **5,** 206; **6,** 197; **7,** 153; **8,** 144; **9,** 129; **10,** 119; **11,** 98; **12,** 76; **13,** 106; **14,** 113; **15,** 141; **16,** 148; **17,** 175; **18,** 186; **19,** 189; **20,** 211; **21,** 220; **22,** 252; **23,** 227; **24,** 189; **25,** 171; **26,** 166; **27,** 155; **28,** 138; **29,** 110; **30,** 112; **31,** 97. Mean for July, 160.4.

August 1, 102; **2,** 126; **3,** 132; **4,** 126; **5,** 116; **6,** 142; **7,** 125; **8,** 126; **9,** 114; **10,** 90; **11,** 97; **12,** 95; **13,** 109; **14,** 133; **15,** 163; **16,** 173; **17,** 175; **18,** 175; **19,** 173; **20,** 125; **21,** 112; **22,** 95; **23,** 86; **24,** 99; **25,** 145; **26,** 144; **27,** 167; **28,** 191; **29,** 210; **30,** 236; **31,** 228. Mean for August, 139.7.

THE LUNAR CRATER PLATO

Jackson T. Carle's article "Three Riddles of Plato," in the April, 1955, *Sky and Telescope,* encouraged me to begin observations of the details on the floor of this crater, using an 8-inch f/7.5 reflector.

Sketches on several nights of poor seeing showed only a few of the interior craterlets. But on August 12, 1957, seeing was superior when the accompanying drawing was made at 11:30 p.m. Central standard time. The terminator of the waning moon passed across Mare Crisium then, the sun's colongitude being 120°.7.

No fewer than 26 craterlets and small bright spots inside the crater were drawn. Most of them were found with 200x, and others were detected with 400x and 600x. For one brief instant of perfect seeing, the dark velvety floor of Plato appeared to be covered with still other minute spots.

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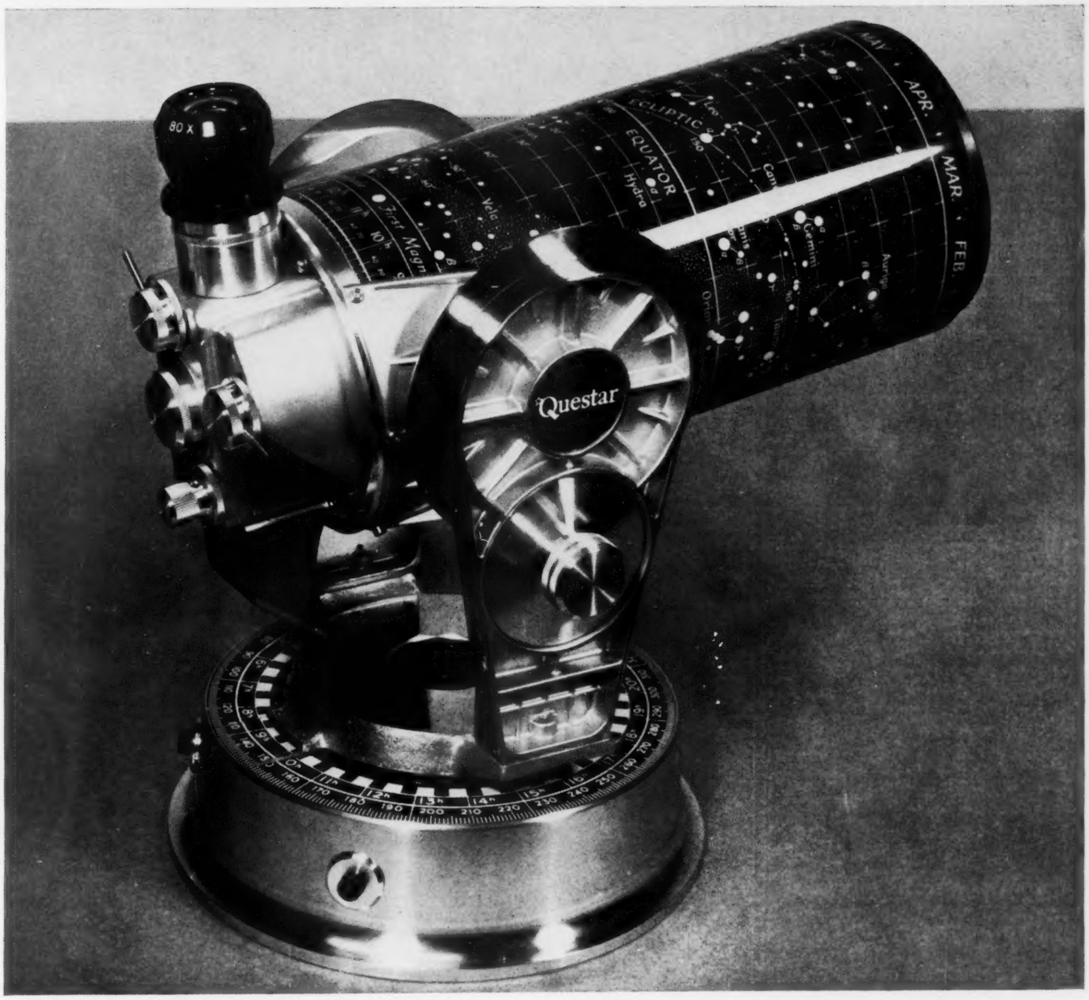


QUESTAR GUARANTEES 0.9-SEC. RESOLUTION

ON NATIONAL BUREAU OF STANDARDS TEST CHART. FINAL TEST RECORD AND CHART COMES WITH EVERY INSTRUMENT.

If telescopes are guaranteed at all, as they ought to be, they are usually guaranteed to equal their theoretical resolving power. For Questar's 3½-inch aperture the Dawes limit is 1.3 seconds of arc. Since nature seems to favor small apertures of some 3 to 5 inches, a telescope in this size range is poor indeed if it cannot meet its theoretical limit of resolution. It therefore seems to us that such a guarantee means little. Further, it puts the burden of proof entirely on the purchaser.

Absolutely tremorless and quiet air is essential to the testing of a telescope if you really want to know how well it will perform. When an instrument is tested on the night sky, the rays of light that reach it must traverse the earth's entire atmosphere. The least movement in the disc and ring system of a star image is evidence of atmospheric interference, as W. H. Pickering has pointed out. Bell tells of a famous English astronomer who "had seen but one first-class night in 15 years." One Questar owner observed for two years before a night of exceptionally fine seeing revealed his instrument's full capabilities. This all sounds discouraging, but we are speaking of not just good seeing, but of seeing that is perfect.

We can make our own perfect seeing by drastically shortening the air path through which we look to read the proper test chart, and this will demonstrate precisely the resolving power of a telescope in seconds of arc. The charts we use are purchased from the Bureau of Standards. They may be used outdoors in the quiet air of early morning or late afternoon at distances up to 300 feet, or even indoors at only 41 feet.

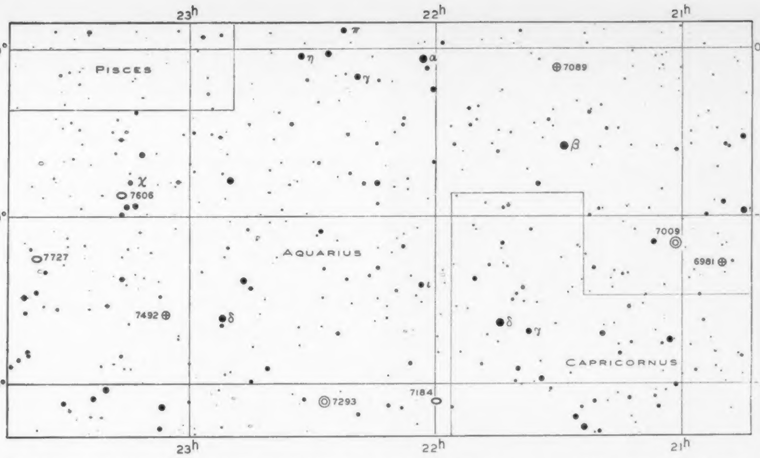
Here is a method of testing telescopes on which we can base a performance guarantee and at the same time furnish the simple means to prove it. We do not ask the novice to familiarize himself with star or planetary test objects, and then wait weeks or months for steady air to look through. The man who buys a Questar now may have room to test it indoors the very day it arrives, regardless of the wind or rain or cold of outside weather. He can duplicate our test himself; the chart will tell him at a glance whether his 3½-inch Questar resolves the 0.9 second of arc that we guarantee.

In going to the chart system, we only do what the Air Force and other photographic people have been doing for years. They have to know the exact quality of some very large and costly lens systems, and various kinds of charts and patterns for this purpose are in common use.

In consulting the experts at the Bureau of Standards on our special needs, they suggested that we use a chart which they make photographically on glossy paper, the smallest lines of which cannot be seen with the naked eye. The Bureau's recommendations for its proper use are embodied in the directions which we send with every chart.

The De Luxe Questar sells complete with all accessories at $995. The Field Model at $495 consists of the same major optics in a simple barrel without built-in auxiliary devices, with bracket casting for mounting on a panhead tripod, 40x eyepiece and choice of star diagonal or erecting prism. This model will accept 1¼-inch standard eyepieces.

QUESTAR CORPORATION
New Hope, Pennsylvania



Positions of the eight deep-sky objects described below are plotted on this chart, which shows stars to apparent visual magnitude 7.75.

DEEP-SKY WONDERS

AQUARIUS, a large constellation well placed for observing this month, contains a variety of objects for the amateur with a not-so-small telescope. Their locations are shown on the accompanying chart prepared from the Skalnate Pleso *Atlas of the Heavens,* which is useful for this study, as it contains many objects not included on older charts.

NGC 6981 (M72) is on all the charts, for the Messier clusters and nebulae are among the brightest in the sky. This globular cluster, situated at right ascension 20^{h} $50^{m}.7$ and declination $-12°$ 44′ (1950 co-ordinates), is five minutes of arc in diameter; its total light matches that of a 9th-magnitude star. In a 10-inch reflector it appears as a dense swarm of faint stars. Nearby on some maps is the nonexistent cluster M73, actually only a grouping of four stars. Those who still write that they can discern a nebula or cluster here might well consult Admiral Smyth's *Celestial Cycle,* where, in his account of M72, he wrote over a century ago that M73 does not exist.

NGC 7009, the Saturn nebula, curiously is not on the Messier list, although it is one of the show objects of the sky. On an extra fine night look for it at 21^{h} $01^{m}.4$, $-11°$ 34′. This planetary is 44 by 26 seconds of arc in size, and of magnitude 8.4.

Beginners will also want to see NGC 7089 (M2), to be found at 21^{h} $30^{m}.9$, $-1°$ 03′. This is another globular cluster, a tight ball of stars 12 minutes in diameter, which glows at 7th magnitude. A 2-inch will show it well on a good night.

These three are the great well-known objects in the constellation, but the Skalnate Pleso *Atlas* shows others that tempt experienced seekers of deep-sky wonders. NGC 7184 is a spiral galaxy at 21^{h} $59^{m}.9$, $-21°$ 04′, discovered by Sir William Herschel. Although only of about the 12th magnitude, its lenticular 5-by-1-minute shape is usually easily discerned.

At nearly the same declination as NGC 7184, but farther east, is the great planetary nebula of Aquarius, NGC 7293, 15 by 12 minutes of arc, situated at 22^{h} $27^{m}.0$, $-21°$ 06′. This was not seen by the early celestial explorers, for although it has a total magnitude of 6.5, its surface brightness is very low. It is a challenge to the observing amateur. The problem of measuring the distances of this and other planetaries was discussed by Otto Struve in the August issue, page 468, and NGC 7293 was pictured on page 208 in his article last March.

There are three interesting objects in the northwestern part of Aquarius. The globular cluster NGC 7492 can be picked up at 23^{h} $05^{m}.7$, $-15°$ 54′. Only 3.3 minutes in diameter and of the 12th magnitude, this is a difficult object, and its true nature is not obvious even in fair-sized telescopes.

Nestled in the midst of some naked-eye stars in NGC 7606, a spiral galaxy at 22^{h} $16^{m}.5$, $-8°$ 46′, appearing as a narrow oval about six minutes long, its magnitude published as 11.5. Herschel, the first who saw it, described this nebula as easy, and it still is today.

Finally, the spiral galaxy NGC 7727, of magnitude 10.7, is located at 23^{h} $37^{m}.3$, $-12°$ 34′. It is an easy object in my 10-inch, shapeless and about two minutes in diameter.

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OCCULTATION OF SATURN

On August 31st, the disappearance of Saturn behind the moon could be successfully observed from New Orleans, although the two objects were so low in the southwestern sky as to be among trees. The gradual approach of Saturn to the moon's dark edge was recorded photographically with a $3\frac{1}{4}$-inch refractor on Plus-X film, by projection through a 40x eyepiece.

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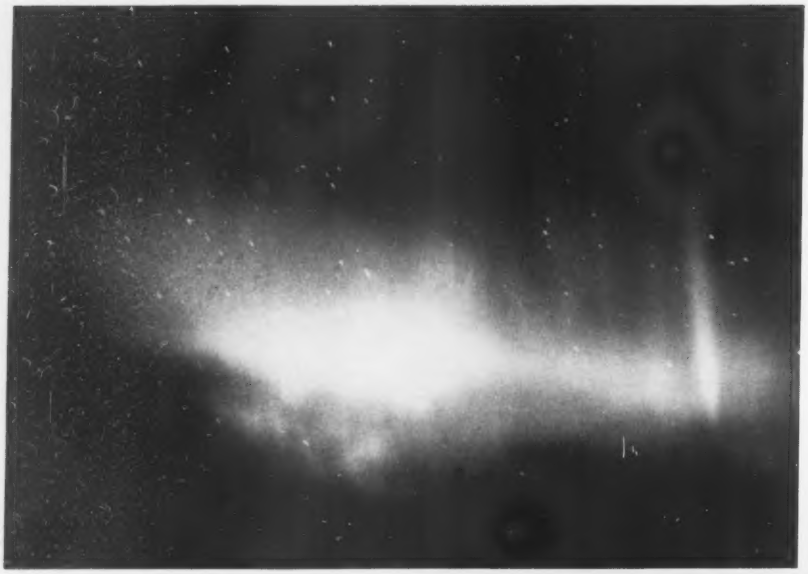


SEPTEMBER AURORAE

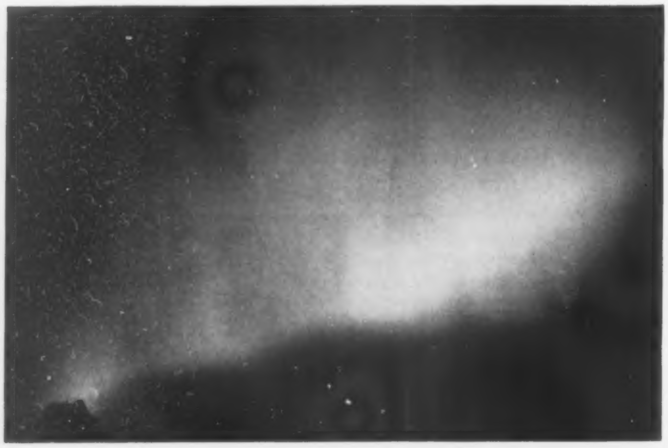
DURING the great September naval maneuvers conducted in the North Atlantic by the combined fleets of the NATO powers, much difficulty was encountered in maintaining radio communications. This was a consequence of the intense solar activity during that period, which resulted in widespread and protracted disturbances of the earth's ionosphere and magnetic field. Teletype messages were garbled, and millions of Americans complained of the poor television reception that resulted from the sun's disturbed state.

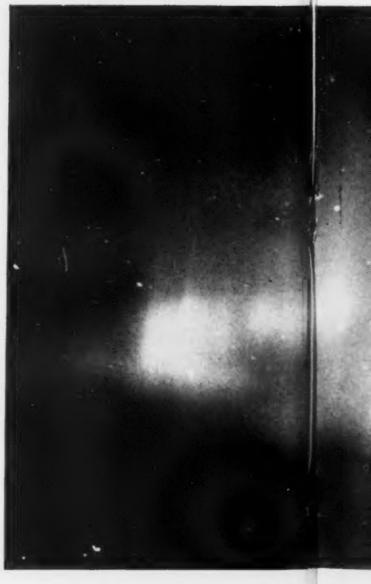
In almost every part of the country, amateur astronomers observed through September a remarkable series of northern lights. The month was in its opening hours when Theodore L. Agos, of Worcester, Massachusetts, secured the pictures reproduced here, of a very brilliant display seen low in the northern sky from the summit of Mt. Wachusett.

He pointed his Super Ikonta B camera in the directions northwest, north-northwest, and north. By means of such star groups as the Big Dipper, the pictures have been matched in azimuth, to make evident the pronounced changes in position and form of the auroral features in the intervals between the two-minute exposures.

Another reader of this magazine, Dr. J. R. Otoupalik, reports a spectacular aurora at Greeley, Colorado, two mornings later, about 3 a.m. Mountain standard time on September 3rd. From the northern quarter of the horizon, greenish-white rays extended 70 degrees up the sky, with the rising flashes that characterize a flaming aurora. A photograph of this same event, by A. J. Morehouse at Battle Creek, Michigan, is shown on this page.

Both of these displays were dwarfed by the widespread auroral storm on the evening of September 4th, which was extremely brilliant despite the presence in the sky of the moon only four days before its full phase. This display is perhaps to be classed with the greatest aurorae of the past few decades. From as far south as Batesville, Arkansas, J. R. Wright reports: "I first noticed the spectacle as a yellow-





Above and right: Three views of the fine northern lights on September 1st, photographed about 12:30 a.m. EST by T. L. Agos in central Massachusetts. He used an f/2.8 lens and Kodak Royal-X Pan 120 roll film. The nearly horizontal handle of the Big Dipper appears at the right in the second picture and the bowl is in the third picture.

Left: On September 3rd, about 3 o'clock in the morning, A. J. Morehouse at Battle Creek, Michigan, secured this one-minute exposure on Tri-X film at f/4.5. He pointed his Kodamatic camera 20 degrees up the northwestern sky.

green glow in the north at 8 p.m. Central standard time. By 9:40 p.m. the aurora reached the height of its activity. At that time there was a bright rayed arc in the north with rays that formed, moved toward a point south of the zenith, and faded. The dominating color of the forms was red, although the lower edge of the rayed arc was yellow-green. By 10 o'clock the rayed arc and rays had disappeared."

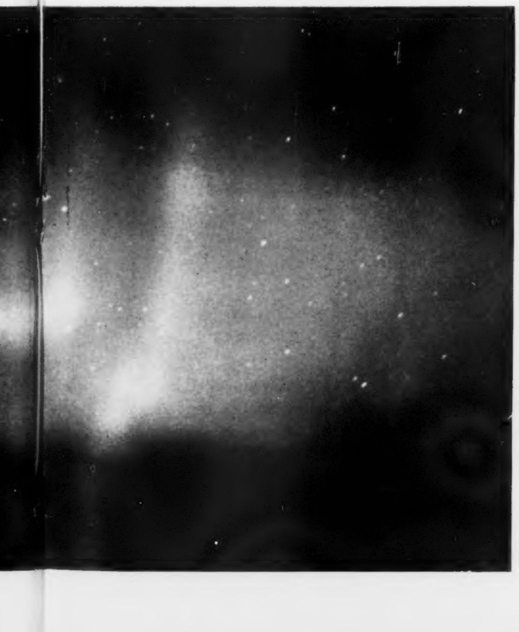
Other more northerly observers, favorably placed geographically, describe the spectacular corona. Kimball I. Jack, of Spokane, Washington, observed at Glacier Park in Montana, where northern lights covered three-fifths of the sky. He tells how rays like searchlight beams reached from the horizon practically to the zenith, converging near the constellation Lyra. But the region of convergence was dark and circular, appearing much like an open umbrella with a hole in the top. The coronal rays extended at least 15 degrees into the southern sky. Although remaining fixed in position, these features alternately faded and brightened.

Dale P. Cruikshank and R. J. Welch relate their impressions of the September 4th aurora, observed at Des Moines, Iowa, between 9:35 and 10:52 p.m. CST:

"It was the finest display seen this year. At one time, for about five to seven minutes, the aurora completely covered the entire sky, which was very clear. The gibbous moon (31 degrees above the south horizon) was engulfed, and streamers could be seen extending to the southern horizon between the trees."

These two observers noted the extreme rapidity of pulsations of the auroral forms; at 9:45 p.m. the northern sky was so bright that the 1st-magnitude star Capella could not be distinguished. Mr. Welch had already seen a twilight aurora that evening, marked by rapid pulsations.

Mrs. C. E. Fencken, at Hoopeston, Illinois, watched from 8:55 to 10:30 p.m. CST. Toward the display's climax two very large and bright red patches formed in the east and west.



Other reports of September 4th have been received from C. E. Ott, Norwalk, Wisconsin; I. Alexeff, Madison, Wisconsin; T. V. Eynden, St. Bernard, Ohio; and R. R. Powell, Lawrence, Kansas.

Auroral activity continued at a high level throughout the month. Another bright display was observed only four days after full moon by Walter A. Feibelman, who makes systematic photographic records at Pittsburgh, Pennsylvania, in cooperation with the IGY Auroral Data Center at Cornell University. He commented on the wide extent of this aurora, reaching far into the west and southwest. A bright red spot appeared near the close of the display.

The September 4th aurora was so bright at Pittsburgh that Walter A. Feibelman's photograph, at 11:03 p.m. EST, shows the rayed structure very distinctly, despite the interference by clouds and bright moonlight. Mr. Feibelman noted that maximum auroral intensity occurred near 10:50 or 10:55 p.m. Some of his pictures record rayed arcs with the parallel rays very thin and numerous. As seen elsewhere under better sky conditions, this display was among the most extraordinary in years.

A noteworthy auroral storm on the night of September 22-23, widely seen over the United States, is discussed by James E. McDonald in his article on page 14. R. T. Morehead, at Des Moines, Iowa, describes this aurora as consisting of rays converging on the zenith, some extending down nearly to the southern horizon. Almost half the sky was brilliant red at the height of the display, a few rays appearing almost blood red; in the northern sky, however, the forms were mainly greenish white.

On the West Coast, at Vancouver, British Columbia, Terry Taylor watched the peak of the September 22nd display at 8:50 p.m. Pacific standard time. He writes, "The corona had grown into a spectacular red-and-white whirlpool of milky light, with a clear spot in the center. Bright rays covered over 75 per cent of the sky, nearly obliterating the 2nd-magnitude stars in Cassiopeia. In the densest regions of the corona even Vega and Deneb looked inconspicuous."

The next night, September 23-24, all the stages of development and decay of a lesser aurora at Pittsburgh were photographed by Mr. Feibelman within less than an hour.

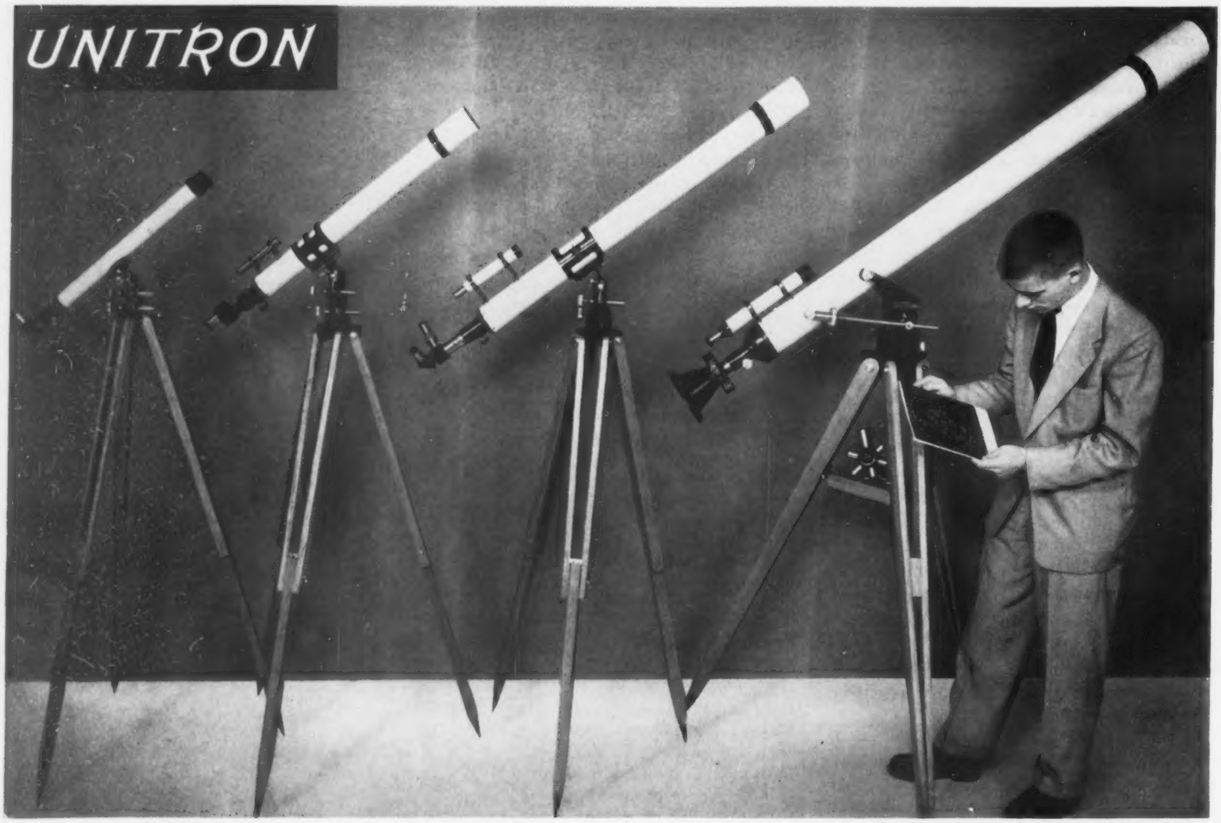
Chris Schell saw two aurorae during the month, one on the morning of September 2nd from Ithaca, New York, the other on September 29th from Pittsfield, Massachusetts. The latter was mainly a drapery formation, with strong red patches.

The northern lights reported here can at best comprise only a small part of the total auroral activity during this memorable month, for they are merely a sampling from a limited geographical area. Only when systematic records of the IGY's world-wide auroral program have been analyzed will the over-all story be learned.

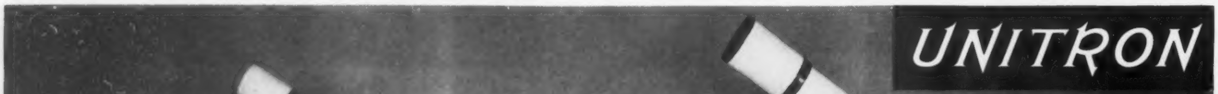
COMET MRKOS AND SOLAR ACTIVITY

Recent photographs of Comet Mrkos, according to astronomers at Yerkes Observatory, show the occurrence in its tail of irregular, changing patches of light. These patches are composed of ionized gases, whose luminosity is caused by jets of fast-moving electrons, protons, and alpha particles ejected from the sun. Similar streams of solar corpuscular radiation that collide with the earth are responsible for the bright northern lights observed during the present peak in the 11-year cycle of solar activity.

Comet Mrkos is the object that was so conspicuous during August, but its rapid recession from the sun has now carried it into the southern sky, where it is very faint.



UNITRON Altazimuth Refractors: left to right, 1.6" (with star diagonal), 2.4" (with erecting prism system), 3" (with DUETRON double eyepiece), and 4" (with astro-camera and with UNIHEX on the shelf).



UNITRON Equatorial Refractors: left to right, 2.4" (with astro-camera), 3" Photo-Equatorial (with sun screen), and 4".

BOOKS AND THE SKY

LIGHT SCATTERING BY SMALL PARTICLES

H. C. van de Hulst. John Wiley and Sons, New York, 1957. 470 pages. $12.00.

ALMOST ALL information used by astronomers comes to us in the form of electromagnetic radiation, or light. For many purposes, it is sufficient to think of the light as traveling unimpeded through empty space from the source to the observer.

Many concepts of astronomy are based on this simplification. For example, in positional astronomy we assume that the light has traveled in a straight line from the star or planet. In calculating absolute magnitudes, or in determining distance through absolute magnitude effects, we assume that the intensity of the light falls off as the inverse square of the distance.

In most cases, however, when we derive physical information about astronomical bodies or the interstellar medium, we have to take into account the interaction between the radiation and the material it is traversing. (Indeed, we must also do this in designing telescope optics for examining the radiation.) When Fraunhofer absorption lines are produced by a stellar atmosphere, the radiant energy does not come to our instruments directly from the source, but is reflected, absorbed and re-emitted many times in the course of its passage. Such interactions form much of the subject matter of astronomy and physics.

Studies of colloidal solutions and aerosols in chemistry, scattering of X-rays in physics, viruses and blood corpuscles for biology, haze, fog, and rain droplets in meteorology, all make use of information derived through the scattering of light by small particles. The work done for one particular application is frequently of use in a completely different discipline.

It is often more important to consider the effect of single small particles one at a time than that of the transmitting medium as a whole. In astronomy this is true for investigations of interstellar and interplanetary dust, as well as of the atmospheres of other planets. For this reason, and in order to make a book of practical size, the author has severely limited its scope.

Processes producing a change in wave length of the light are ruled out. Dr. van de Hulst considers only scattering by well-separated particles, where the interaction can be considered to involve only one particle at a time. He does not discuss multiple scattering, in which the light is scattered again by a second particle.

Within these limitations, perhaps because of them, the book will be invaluable to research workers in many fields, but it is not particularly suitable as a textbook, even for an advanced course in optics. Its primary value will be as a reference providing in one place a logical and concise summary of scattering theory. Its mathematical nature makes the book of little use to most amateur astronomers.

Dr. van de Hulst discusses first the basic theory of scattering. For particles about the size of the wave length of the light involved, actual calculations of scattering are very tedious, and it is not yet possible to compute the scattering by arbitrarily shaped particles for all wave lengths and polarizations. The second and largest section of the book deals with the theories of scattering by many special types of particles. A final section gives some typical applications to chemistry, meteorology, and astronomy, in a brief form sufficient to indicate to the research worker what parts of the scattering theory may be applicable to his particular problem. One of the most important of these in astronomy is the effect of interstellar grains in producing absorption and polarization of light that passes through the space within the galaxy.

The author says that his needs in astrophysical research primarily led him to write this review of the widely dispersed literature on scattering. Nonetheless much of his own work appears in many parts of the volume, indicating his contributions to gaps in the available theory.

ROBERT FLEISCHER
Rensselaer Polytechnic Institute

DISCOVERIES AND OPINIONS OF GALILEO

Stillman Drake, translator. Doubleday Anchor Books, Garden City, New York, 1957. 302 pages. $1.25, paper bound.

FOUR selections from Galileo's works are translated here. An introduction to each piece gives the biographical background and some details on the circumstances that led to its writing.

The first two selections, "The Starry Messenger" and "Letters on Sunspots," are particularly interesting from the astronomical point of view. The former especially conveys the excitement, as well as the brilliance, of Galileo's discoveries on first looking through a telescope. We are reminded that things now taken for granted, such as the irregularity of the lunar surface and the revolution of the satellites about Jupiter, were novel concepts 350 years ago.

In reading these works this reviewer was once more impressed by the genius of this man, who not only saw and described so many things new in his day, but usually interpreted correctly what he saw. This understanding of natural phenomena is particularly impressive in view of the considerable opposition to his ideas.

We may take as an example the case of

the interpretation of sunspots. After careful observations Galileo decided that they were very close to, if not actually on, the solar surface. Learned opinion on the whole was opposed to this, for it implied that there were blemishes on the sun's surface, and that it was not a pure ball of fire, as believed by the Aristotelians.

In the last two essays of the book, Galileo goes into the matter of scientific truth founded on observation and logical deduction, as opposed to authority (particularly Aristotle) and faith. He draws a strong distinction between matters that can be investigated scientifically, and those in the domain of theologians. Such a restricted viewpoint was necessary for survival in Renaissance Europe, but even today many scientific philosophers admit limitations to the methods of scientific thought.

Mr. Drake is to be congratulated for making these works of Galileo available to the general reader. The introductory notes give the background necessary to a fuller understanding of the selections, by describing the circumstances under which they were written. In several cases Mr. Drake points out instances where later work indicated that Galileo had erred. Somewhat more material of this kind might have been included for the benefit of the reader who knows nothing of astronomy.

The selections contained in this volume are all from Galileo's early period, 1610 to 1623. His famous *Dialogue on the Great World Systems* (1638) is not included, but is currently in print.

A lack of knowledge of the original Italian versions of these works prohibits the reviewer from passing judgment on the exactness of the translation, but it reads easily and smoothly. The style is clearly modern, which makes for better reading.

ELSKE V. P. SMITH
Sacramento Peak Observatory

THE LIFE OF ARTHUR STANLEY EDDINGTON

A. Vibert Douglas. Thomas Nelson and Sons, New York, 1957. 207 pages. $6.25.

WRITING the biography of a many-sided genius would have been difficult even under the best circumstances. In Sir Arthur Eddington's case the task is made more difficult because of his shy and retiring nature. As one whose interest in astronomy was kindled by the writings of Eddington, the reviewer had been looking forward to reading this work by Professor Douglas, who was a student and associate of the famous astrophysicist. She has done a commendable job, and fellow scientists will be indebted to her for providing an integrated view of the activities of a truly great scientist.

In the first two chapters are traced as far as is possible the early influences in Eddington's life that shaped his later interests. There is a vivid account of Eddington as a happy young man with prodigious intellectual curiosity and the ability to follow up this curiosity in any field he liked. That circumstances were favorable for his activities is both a commentary on his attitude to life and on the state of the world at that time.

After spending seven fruitful years as chief assistant at Greenwich, Eddington returned to Cambridge in 1913 as Plumian Professor. He was to remain in the same position until his death in 1944. It is sometimes forgotten that Eddington, who is best remembered for his theoretical work, during his years at Greenwich had "to observe at nights a good deal in order to understand the instruments thoroughly."

The author gives a fairly general but interesting account of Eddington's work, beginning with his early studies of star motions, through stellar structure, relativity, and cosmology. In every one of these fields he had the uncanny knack of selecting the most significant problems and creating whole new branches of astrophysics. There is also a lively narrative of his controversies with his fellow astronomers, especially Sir James Jeans. In these controversies we see the growing pains of astrophysics as a subject with its own rules of the game.

Apart from his astronomical researches, Sir Arthur was very active both in the

popularization of science and the development of a philosophy of science. In later life, one of the criticisms by his less broad-minded colleagues was that he mixed mysticism and science instead of using his brilliant analytical talents for scientific study only. As the book indicates, "one of the most powerful factors in the formation of Eddington's intellectual outlook and spiritual perceptivity was the Quaker atmosphere of his home."

In a chapter titled "Concerning the Unseen World," Miss Douglas gives a lucid outline of Eddington's personal philosophy. In these days of unquestioned obedience to specialization this outlook is like a breath of fresh air. One gets a glimpse of the essential morality and the humility of the man who could remark at the end of a classic on stellar structure, "Somewhere in the present tangle of evolution and sources of energy I have been misled: and my guidance of the reader must terminate with the admission that I have lost my way." Eddington did not isolate his scientific work from his philosophy of life, and he felt a deep moral responsibility for all his actions. There may have been more brilliant scientists, but one doubts whether there have been many endowed with his wisdom.

The penultimate chapter is devoted to the most controversial of all Professor Eddington's works. Most of his last years were occupied in building up an elaborate theory of the microscopic and macroscopic structure of the universe. The final portions of this study, entitled *Fundamental Theory*, were published posthumously. The whole work is so abstruse that even a well-known cosmologist remarked, "The analysis . . . is so very complex and based on such extremely difficult arguments that most scientists found themselves unable to examine the theory in detail."

No review of Miss Douglas' book can be complete without commenting on the literary excellence of the biography of a man who was noted for his facility with the pen and the imagery of his descriptions of extremely difficult concepts. Studded with generous quotations from Eddington's writings, this biography will provide fascinating reading for both the professional and amateur astronomer.

T. K. MENON
Harvard College Observatory

OPTICS: THE SCIENCE OF VISION

Vasco Ronchi. New York University Press, New York, 1957. 360 pages. $10.00.

THE DIRECTOR of the National Institute of Optics, Arcetri, Italy, who is well known as the inventor of the Ronchi test for optical systems, has not given us here a textbook in optics, as the title might imply. Rather this is a pioneering work, pleading for a science of vision to bring together those aspects of physics, physiology, and psychology that deal with how we see, both with and without the aid of telescopes and microscopes.

Such a science would not be solely a chapter in physics, where the eye is generally treated as something placed at the eyepiece of an instrument. Nor would this new field be merely a part of physiology, where optical instruments are only devices placed in front of that complex organ, the eye. The science of vision would have a broader outlook than psychology, where the optical instrument and eye are both simply media for transmission of stimuli to certain parts of the brain. There, in a little-understood and seemingly magical manner, arises a vision of a rose garden, a speeding car, or a galaxy in Andromeda. The new science would aim at the totality of what these three disciplines have to say on the subject.

In short, Ronchi would define optics as the science of vision, not merely the study of lenses, the eye, or of stimuli along the optic nerve. This proposal is difficult, but challenging. Physicists are trained in a mathematical framework, the outlook of physiologists is medical, while psychologists move largely in a humanistic environment. Moreover, these three groups of scientists differ in training and in their use of technical terms. Therefore, Ronchi implies that the present division of optics among the sciences not only hampers

progress in understanding vision but propagates error. He gives many convincing examples of such errors.

Ronchi calls the end product of what our eyes perceive the *effigy,* not the image. He explains the distinction between them: "*The image,* whether real or virtual, defined as the locus of the centers of the waves emerging from an optical system, *is a purely mathematical entity, entirely distinct from the figure seen.* Images have a definite position; the figures seen are created and located by the observer, and may be placed by one observer in one way, by another observer in another way. An image is a mathematical entity, the figure seen is a psychological entity. To have identified these two entities was a profound philosophical blunder. To convince millions of people that the two things are the same is one of the most ridiculous aspects of the teaching of science."

This contention is illustrated by a great many examples of effigies obtained with the aid of plane and spherical mirrors, and convergent and divergent lenses. As an instance of the failure of ordinary geometrical optics to account for appearances, Ronchi asks the reader to hold his hand at varying distances of about eight to 24 inches from his eye. Although it should vary in apparent size by a factor of three, the hand seems to undergo a much smaller change.

In presenting his thesis, Ronchi tends to be overzealous, seeming to portray the physicist's concept of optics as a villain. His contentions are, furthermore, not entirely new. The distinction between what we see and what we ought to see, according to the simple lens formulas, has been made by some philosophers, physicists, and teachers of science. In astronomy, "image" means different things to the visual observer and photographic astronomer. To the latter it is a particular distribution of silver grains on a plate, detectable impersonally by a microphotometer. We can distinguish a good photographic image from a poor one, and can judge the resolution by an optical system without once invoking the "effigy" concept which Ronchi holds paramount.

Because the science of vision, as considered in this book, runs directly into the difficult philosophical problems of consciousness, the author encounters semantic difficulties. There are many places where Ronchi, in his anxiety to prove a point, is not strictly fair to geometrical optics.

Despite minor lapses of this kind, wordiness, and some overstatement, this book is a refreshing and thought-provoking critique of the concepts of optics. Teachers will find it helpful, for it certainly clarifies many optical ideas often hard to convey in the classroom. Furthermore, it contains a fine historical survey of optics.

Edward Rosen, associate professor of history, College of the City of New York, ably translated the work from the original Italian.

J. ALLEN HYNEK
Smithsonian Astrophysical Observatory

NEW BOOKS RECEIVED

ROUTE-MAPPING AND POSITION-LOCATING IN UNEXPLORED REGIONS, *Wilhelm Filchner, Erich Przybyllok,* and *Toni Hagen,* 1957, *Academic Press.* 288 pages. $9.00.

This manual for explorers deals with the overlap between practical astronomy and geography. It describes how the traveler in unexplored regions can determine longitudes and latitudes from astronomical observations, and combine them with trail notes and sketches to form a map. Dr. Hagen's contribution to the book is an account of the uses of aerial photography and photogrammetry in map making.

TRANSACTIONS OF THE INTERNATIONAL ASTRONOMICAL UNION, Vol. IX, *P. Th. Oosterhoff,* editor, 1957, *Cambridge University Press.* 802 pages. $15.00.

The ninth general assembly of the IAU, held at Dublin in 1955, has included only its main proceedings in this volume, with symposiums being published separately. This change in arrangement allows the *Transactions* more space for IAU commission reports, which give a very complete survey of progress in all branches of astronomy since the 1952 meeting in Rome.

Also in this volume are the minutes of the general sessions of the IAU at Dublin, all texts of the resolutions adopted, and the statutes and membership list of the union. The text is largely in English, with some sections in French.

NON-STABLE STARS, *George H. Herbig,* editor, 1957, *Cambridge University Press.* 200 pages. $5.50.

The International Astronomical Union held several symposiums at its 1955 general assembly in Dublin, which are being reported in a series of books separate from the IAU *Transactions.* No. 3 of this series is entitled *Non-Stable Stars,* and is edited by a leader in the field, Dr. George H. Herbig, of Lick Observatory.

In this volume are published, in English, 23 contributions covering instability in low-luminosity stars of both late and early types, novae, hot stars of rather high luminosity, late-type variable stars, and close binary systems. Theoretical aspects of stellar instability are also discussed, and the book contains several Soviet contributions not circulated at Dublin.

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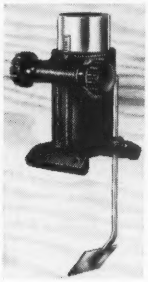

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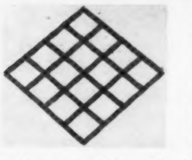

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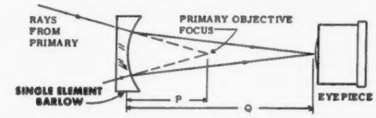

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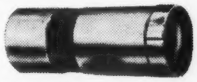

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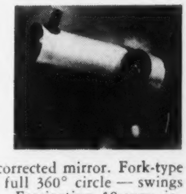

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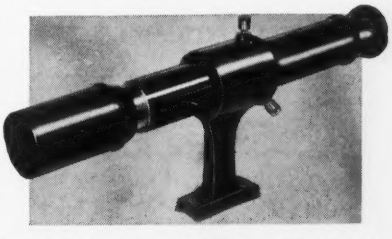

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A New Test for Cassegrainian Secondaries

OPTICAL THEORY teaches that a spherical wave front converges to a point focus and forms an image free from longitudinal aberration. It also makes clear that this condition cannot be obtained with any single spherical surface receiving parallel light. It can, however, be obtained with an aspherical refracting surface.

The required shape of such a surface depends upon its radius and the indexes of refraction of the two media that it separates, **n** for the first medium, **n′** for the second:

A. If light passes from a denser to a less dense medium (as glass to air), the surface must be hyperboloidal, and its eccentricity will be **n**/**n′**.

B. If light passes from a less dense to a denser medium (air to glass), the surface must be ellipsoidal, with an eccentricity of **n**/**n′**.

These two situations are illustrated in Fig. 1 for both concave and convex surfaces, where the media are air and BSC-2 glass with an index of 1.517. The statements above can be verified by trigonometric ray tracing.

Although I came upon these ideas independently in the course of my hobby of ray tracing and telescope making, I later learned from Dr. James G. Baker that they date back to the 17th-century French mathematician, René Descartes, and his investigation of the curves known as Cartesian ovals. These ideas are well explained in M. von Rohr's book, *Theory of the Formation of Images in Optical Instruments,* pages 24 to 26 of the English translation of 1920.

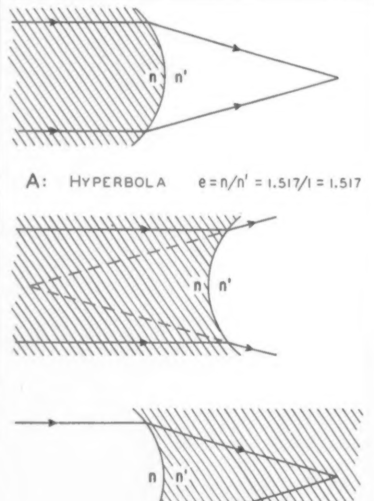


Fig. 1. Various cases of a principle of optics applied by Burt A. Norman in testing a Cassegrainian secondary.

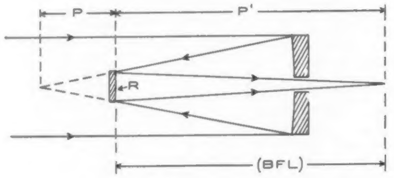


Fig. 2. A sketch of the optics of a Cassegrainian reflecting telescope.

What practical use can be made of this principle? One obvious application is a solution to the difficult problem of making and testing a hyperboloidal secondary mirror for a Cassegrainian telescope. I shall describe here how one can make and test a plano-convex lens, to be figured in the test stages, and the convex surface of this same lens, when aluminized, serves as the secondary mirror!

In Fig. 2 is sketched the Cassegrainian optical system, and in Fig. 3 the testing arrangement. The secondary is tested from the convex side by autocollimation. If a good optical flat is not available for this test, simply silver the plane surface of the lens. Even if the back is not used as a reflecting surface, it should be flat to less than 1/8 wave; polish need not be perfect.

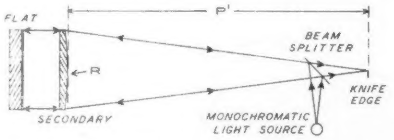


Fig. 3. The test setup as used when an optical flat is available.

For a Cassegrainian whose secondary mirror is located the distance **P** inside the primary focus, the secondary's back focal length being **P′**, the following relationships are well known:

Radius of curvature of central zone

$$\mathbf{R} = 2\mathbf{P'P}/(\mathbf{P'} - \mathbf{P}),$$

Eccentricity of hyperboloid

$$\mathbf{e} = (\mathbf{P'} + \mathbf{P})/(\mathbf{P'} - \mathbf{P}).$$

The design is chosen so that the eccentricity is numerically equal to the refractive index of some easily obtainable type of glass. From this glass make a plano-convex lens having a radius of curvature equal to **R**, and a paraxial back focal

length of **P′**. In the test, light passes through the lens twice, and the glass must therefore be of the best grade-A quality, fine annealed. The lens is to be of the diameter required for the telescope's secondary mirror, and before the test it should be edged circular, accurately centered, and wedge free.

Instead of the usual off-axis Foucault setup, use a beam splitter to insure that the light source and knife edge lie exactly on the optical axis of the lens. Figure the convex surface of the lens (changing it from a sphere) until a null test is obtained. This means that the knife-edge cutoff produces an even darkening all over the surface at one time, just as if a spherical mirror were being tested. But with this test, the refractive index of the glass introduces a correction so that the figuring will produce the desired aspherical surface on the lens. When the null test is perfect, the lens has become a hyperboloidal secondary ready for aluminizing and installation in the telescope.

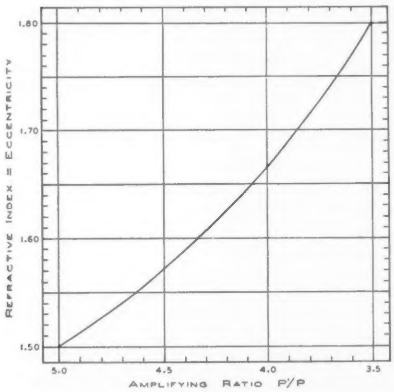
There is a practical restriction on the application of this testing method to a particular telescope. The factor by which the secondary mirror increases the focal length of the primary is called the amplifying ratio, **P′/P**. The glass selected for the lens must match the design, having the proper refractive index for the wave length of the test light. For example, if sodium light is used for the test source, then a secondary made from **BSC-2** glass must have an amplifying ratio of 4.87.

Most amateurs will probably find it best to procure the glass for the lens before completing the telescope design. Fig. 4 is a graph that tells the amplification for any glass having a refractive index between 1.5 and 1.8. With standard types of glass (Fig. 5), the amplification must be between $3\frac{1}{2}$ and 5, but this should not prove a handicap, for most amateur Cassegrainians actually have this ratio between 4 and 5.

To find the paraxial focal length of the test lens from Fig. 4, read off the amplifying ratio and multiply this figure by **P**. For greater accuracy, use the formula

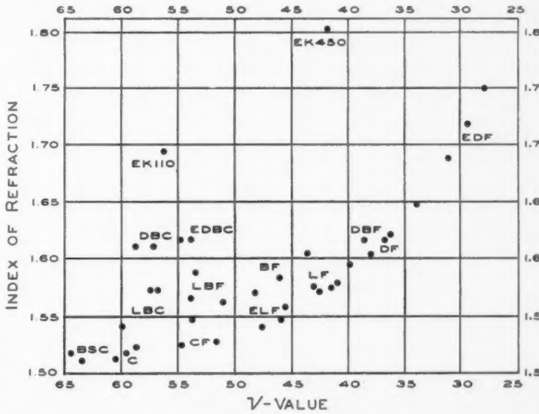
$$P' = P(e + 1)/(e - 1).$$

Catalogue No. 4 of the Hayward Glass Corp., 217 Magnolia Ave., Whittier, Calif.,



Left: Fig. 4. A graph relating index of refraction to amplifying ratio in the Norman test for Cassegrain secondaries.

Right: Fig. 5. This chart from Eastman Kodak Co. gives the indexes of refraction for some common types of glass. The abscissa of the chart is the nu-value, or reciprocal dispersion; it is not involved in the Norman test, where monochromatic light must be used.



lists various types of optical glass, with their indexes for different colors of light, such as the mercury green line and the sodium yellow line. Bausch and Lomb Optical Co., Rochester 2, N. Y., also makes optical glass. To be very exact, specify when ordering that you wish to know these indexes for the particular melt of glass, because each batch of glass is slightly different.

Choice of the light source for this test is of great importance. The old trick of rubbing salt into the wick of an oil lamp to get sodium light does not give enough brightness. A sufficiently bright mercury light source that costs less than five dollars, the General Electric F4T 5/BL black-light lamp, has been suggested to me by Robert E. Cox. Do not get the BLB lamp, for it has a coating that passes only invisible light and is useless as a test source.

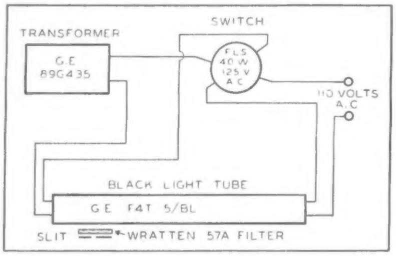


Fig. 6. The arrangement of parts in an inexpensive mercury light source.

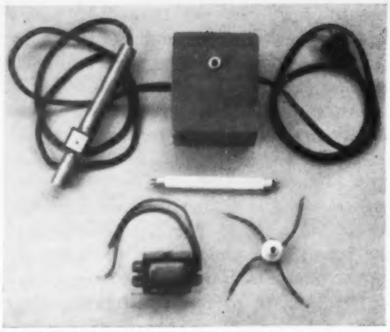


Fig. 7. The mercury light source disassembled. The black-light tube fits into a metal container seven inches long. At the front are the transformer and four-wire switch. Photo by Robert E. Cox.

The ballast is a General Electric 89G435 transformer. In the wiring diagram for the light source, Fig. 6, the four-wire on-off switch is an FLS 40-watt, 125-volt a.c. switch, obtainable from Sears Roebuck or other stores handling fluorescent lamps. The parts are seen in Fig. 7.

To isolate the green mercury line at 5461 angstroms, an Eastman Kodak Wratten 57A filter is recommended; a two-inch square of this material in gelatin costs 60 cents. The same filter can be obtained glass-mounted (grade B is satisfactory), if this more permanent form is worth the higher price.

Other monochromatic light sources that should be investigated are the Osram spectral lamps available from Edmund Scientific Co., Barrington, N. J. The helium, mercury, and sodium Osram lamps should be bright enough for testing the secondary mirror. They are listed at $29.50, but other electrical components needed to energize these lamps will run the total cost to over $45.

This test method is only one of the possible applications of the principle of Cartesian ovals to optical design, a principle which is less familiar to amateur telescope makers than it should be. Probably $\mathbf{e} = n/n'$ can benefit the amateur optical worker in other ways.

BURT A. NORMAN
Franklin Center
Quebec, Canada

ED. NOTE: The test proposed by Mr. Norman is not a familiar one to optical designers, and it may be appropriately called "the Norman test." Mr. Norman is a native of Arkansas, and has been a construction engineer at hydroelectric, chemical, and other industrial plants, as well as the Chalk River project in Ontario.

The well-known optical designer, Dr. James G. Baker, comments, "A fine practical application of a very old principle. I do not recall having seen this optical theorem used for a Cassegrainian test. This is a good example of the contribution that amateurs can often make to optics."


Japan's Finest Telescopes now available to World Astronomers
GOTO TOKYO
This is the 4" Equatorial Telescope which was recently manufactured and delivered to Mr. A.T. Graves of 9 Synswyck Road, Darien, Connecticut, famous industrialist and amateur astronomer, who placed a special order for its manufacture during his stay in Tokyo.
That the quality of this telescope has come to be recognized can be seen from the recent increase in the numbers exported. For example, they were directly shipped to:
Sainte-Marie College
1180 Rue Bleury, Montreal 2, Canada.
Dr. S. von Numers
The Legation of Finland, Ottawa, Canada.
Aside from direct exports many are now being shipped indirectly overseas through various sales agents to the United States and Latin America attesting to their growing worldwide popularity.
Achromatic Objectives
For use in astronomical telescopes. Mounted in cell.
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Oculars—Fit American size barrel.
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(Prices including shipping costs) The above prices also include the anticipated import duties so in making remittances 25% should be deducted from the listed prices.
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A Versatile Observing Setup with an 8-inch Reflector

After several years of making and observing with many small instruments, I have constructed an 8-inch reflector which combines fine optics with versatility and rigidity.

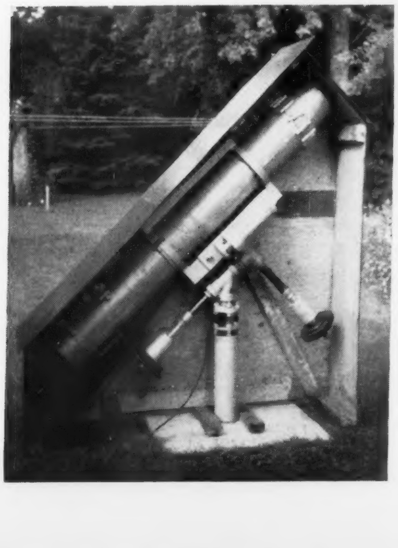
The heart of this telescope, an 8-inch f/7.5 paraboloidal mirror, is mounted in a hardwood cell similar to that described in Allyn J. Thompson's *Making Your Own Telescope.* The cell holds the mirror without flexure and has never needed realigning. The mirror is housed in a welded, cork-lined, 10" aluminum tube.

At first I used a circular spider to hold my elliptical flat, but since this was not perfectly rigid, I made a three-legged spider and used an antidiffraction mask on the mirror (*Sky and Telescope,* April, 1957, page 289). The arrangement gives fine refractor-like star images and insures alignment.

The equatorial mounting of 2½" pipe fittings has 1½" axles which rotate in iron bushings. I have a prime-focus camera attachment, and an electric exhaust fan to control air currents in the tube. Recently I completed a patrol camera, the lens being a 75-mm. f/4.7 war-surplus anastigmat. The 8-inch is used as a guide telescope, and I guide by hand since an electric clock drive is still to be completed. With very fast Royal-X Pan cut film (ASA rating 1600), I have secured good star images to the 9th magnitude with a 90-second exposure.

On one side of the hardwood saddle is a 3-inch reflector, which serves as a counterweight for the patrol camera on the other side of the declination axis. When the clock drive is finished, the smaller reflector will serve as a guide telescope for longer exposures with the 8-inch.

Right: Don Parker finds that an old oil drum, formerly used as a support for mirror grinding, makes a convenient observing chair for lunar and planetary observing. Attached to the drum is a basket that holds the eyepiece box, as well as an easel with the clipboard he uses for drawings and making notes.



Below: Before the Parker telescope can be covered with its compact-fitting plywood shelter, the tube must be turned into the meridian and pointed to the north pole of the sky.

The performance of the telescope has been very satisfactory. I have detected, for instance, three of the minor divisions in Saturn's rings, and have observed much detail on Mars, including 11 canals last summer. I have seen 10 spots and craterlets on the floor of Plato, a lunar feature that I study regularly. My chief interest is in lunar and planetary work.

Moving the telescope's mirror and tube indoors after observing is dangerous and time consuming, so I have constructed the plywood shelter illustrated here. One of the sides is fastened by means of five wing nuts; when these are removed the rest of the weatherproof covering can be easily slid away.

DON PARKER
595 Braeside Rd.
Highland Park, Ill.

CELESTIAL CALENDAR

Universal time is used unless otherwise noted.

MINOR PLANET PREDICTIONS

Dembowska, 349, 9.5. November 8, 5:07.5 +29-51; 18, 4:59.8 +30-18; 28, 4:50.2 +30-36. December 8, 4:39.8 +30-42; 18, 4:29.8 +30-37; 28, 4:21.5 +30-26.

Juno, 3, 7.1. November 8, 5:15.3 +0-33; 18, 5:10.8 −0-54; 28, 5:04.0 −1.55. December 8, 4:55.8 −2-24; 18, 4:48.0 −2-16; 28, 4:41.8 −1-33.

Kleopatra, 216, 8.6. November 8, 4:33.0 +12-49; 18, 4:25.8 +10-59; 28, 4:17.5 +9-19. December 8, 4:09.5 +7-57; 18, 4:03.0 +7-01; 28, 3:59.0 +6-30.

Melpomene, 18, 8.3. November 8, 4:57.7 +2-42; 18, 4:50.1 +1-55; 28, 4:40.5 +1-34. December 8, 4:30.5 +1-45; 18, 4:21.9 +2-26; 28, 4:15.9 +3-32.

After the asteroid's name are its number and the magnitude expected at opposition. At 10-day intervals are given its right ascension and declination (1950.0) for 0^h Universal time. In each case the motion of the asteroid is retrograde. Data are supplied by the IAU Minor Planet Center at the University of Cincinnati Observatory.

VARIABLE STAR MAXIMA

November 2, RS Herculis, 171723, 8.0; 2, T Normae, 15**3654**, 7.4; 3, Omicron Ceti (Mira), 021**403**, 3.7; 4, R Normae, 152**849**, 7.2; 6, R Indi, 222**867**, 8.0; 18, S Gruis, 221**948**, 7.8; 18, T Centauri, 13**3633**, 6.1; 29, R Leonis Minoris, 093934, 7.2.

December 2, R Andromedae, 001838, 7.0; 2, T Ursae Majoris, 123160, 7.9; 5, R Draconis, 163266, 7.6; 5, R Horologii, 025**050**, 6.0; 8, S Canis Minoris, 072708, 7.5; 9, RR Scorpii, 165**030**, 6.0.

These predictions of variable star maxima are by the AAVSO. Only stars are included whose mean maximum magnitudes are brighter than magnitude 8.0. Some, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern), and the predicted magnitude.

OCCULTATION PREDICTIONS

November 8-9 **Epsilon Tauri** 3.6, 4:26.1 +19-05.2, 17. Im: **F** 10:27.0 −1.9 +0.1 69; **H** 9:42.0 −2.2 +1.5 56. Em: **F** 11:37.9 −0.8 −1.9 294; **H** 10:58.8 −1.9 −2.0 296.

November 11-12 **Lambda Geminorum** 3.6, 7:15.6 +16-37.2, 20. Im: **B** 11:10.3 −0.6 −2.8 146; **D** 11:13.0 −0.4 −3.9 162.

For stations in the United States and Canada, usually for stars of magnitude 5.0 or brighter, data from the *American Ephemeris* and the *British Nautical Almanac* are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, UT, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computation of fairly accurate times for one's local station (long. **Lo,** lat. **L**) within 200 or 300 miles of a standard station (long. **LoS,** lat. **LS).** Multiply **a** by the difference in longitude **(Lo — LoS),** and multiply **b** by the difference in latitude **(L — LS),** with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

A	+72°.5,	+42°.5	**E**	+91°.0,	+40°.0
B	+73°.6,	+45°.5	**F**	+98°.0,	+31°.0
C	+77°.1,	+38°.9	**G**	Discontinued	
D	+79°.4,	+43°.7	**H**	+120°.0,	+36°.0
I	+123°.1,	+49°.5			

MINIMA OF ALGOL

November 2, 10:05; 5, 6:53; 8, 3:42; 11, 0:31; 13, 21:20; 16, 18:09; 19, 14:58; 22, 11:47; 25, 8:36; 28, 5:25. December 1, 2:14; 3, 23:03; 6, 19:52; 9, 16:41.

These minima predictions for Algol are based on the formula in the 1953 *International Supplement* of the Krakow Observatory. The times given are geocentric; they can be compared directly with observed times of least brightness.

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Classified advertising costs 20 cents a word, including address; minimum charge, $3.00 per ad. Only one *for sale* ad per issue for each advertiser. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the 20th of the second month before publication; otherwise, insertion will be made in next issue. We cannot acknowledge classified ad orders. Sky Publishing Corporation assumes no responsibility for statements made in classified ads, nor for the quality of merchandise advertised. Write Ad Dept., *Sky and Telescope*, Harvard Observatory, Cambridge 38, Massachusetts.

FIRST-QUALITY achromatic objective: Main objective from the 13½′ M-1 height finder. Clear aperture, 62 mm. (2-7/16″); focal length, 470 mm. (18.5″). Beautifully air-space mounted in 3¼″ long tube. $12.50 postpaid. Some matched pairs at $25.00 per pair. A. Cottone Co., 340 Canal St., New York 13, N. Y.

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BEGINNER'S Telescope Kit: $3.00 each, all parts, and 3 lenses. Make 8-power astronomical telescope described in September, 1949, *Sky and Telescope*. Frank Myers, 19200 N. Park Blvd., Shaker Heights, Ohio.

MELLISH 7¼″ telescope, 100″ focal length; objective chipped four places thumbnail size; 6 eyepieces; tripod pipe mounting; no finder. $350.00. W. E. Johnson, 42 Sauk Trail, Park Forest, Ill.

METEORITES: Visitors from space. Genuine, guaranteed. Use for research, lectures, and demonstrations. Individually complete, $1.00, $3.00, $6.00, $10.00, $15.00. Scientific Laboratory, 2846 Oakley Ave., Baltimore 15, Md.

ASTROLA 8″ f/7, clock drive, excellent condition, no oculars, best offer takes it. Bruce Covey, 251 Miller Lane, Rochester 17, N. Y.

REFRACTOR, 3″, achromatic, altazimuth. Made by advanced amateur. Brass tube and fittings. Tripod and case. $98.00 postpaid. Don D'Entremont, 404 Beale St., Wollaston 70, Mass.

RIGID, accurate, low-cost fork scope mounts, 4″ to 24″, 10″ to 24″ circles, micro set in right ascension and declination, with drive. Write your needs to Mather Machine Works, Clarksville, Iowa.

PRACTICAL, new "Bibliography for ATM's," second edition, 8 pages, 25¢. Kelvin Masson, 338 Plaza Ave., St. Louis 21, Mo.

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FOR SALE: 2.4″ Unitron equatorial, sun screen, Barlow lens, $190.00. W. L. Wilie, Jr., 1405 McFaddin, Beaumont, Tex.

ARTIFICIAL-STAR pinholes, .002″ in .0015 brass, $1.00 each. Carl Hand, 1111 Lundvall Ave., Rockford, Ill.

SPECIAL SALE: 8″ reflector. Slight defect does not affect optical performance. Needs only base. $75.00. Duane Allman, 534 South 67th, Milwaukee, Wisc.

COMET SEEKERS: 5″ aperture, 20″ e.f.l., mounted telescope, $175.00. Schmidt cameras, any size and focal ratio, typical prices: 7.5″ aperture with 10″ mirror f/2.8 (optics only), $400.00; mounted, $750.00. Arthur De Vany, 1580 S. Ynez Ave., Monterey Park, Calif.

FOR SALE: 8″ f/8 mirror, unaluminized, ¼-wave paraboloid, pyrex. Asking $55.00. Daniel Kahan, 805 Longshore Ave., Philadelphia 11, Pa.

EXCHANGE VISIT: English amateur, 21, awaiting Cambridge, England, wishes to visit with an American amateur, September, 1958. Return visit later. Write, giving details, to Julian Barbour, South Newington, Nr. Banbury, Oxon, England.

FOR SALE: 2.4″ Unitron altazimuth with all standard accessories. Bought last year. $75.00 f.o.b. Oakland. Carl Backlund, 1200 Alpine Rd., Apt. 50, Walnut Creek, Calif.

BARDOU TELESCOPE: 2⅞″ clear aperture, 3 eyepieces, altazimuth mounting; owned by astronomy club. Send bids over $110.00 or write for information to Rasmussen and Reece, Amsterdam, N. Y.

FOR SALE: 7 x 50 binocular eyepieces, spiral focusing, coated eye lens, $3.00 each. Height finder objectives, 2-3/64″ diameter, coated, achromatic, 9″ focal length, in threaded metal cell, $5.00 each. Prisms, right-angle, ⅞″ x ⅞″ face, 1-5/16″ hypotenuse, $1.00 each. Tank periscope prisms, right angle, 2⅛″ hypotenuse, 5¾″ long in metal and plastic housing, two for $1.50. All postpaid. Satisfaction or money refunded. Charles E. Roberts, 730 4th St., Fremont, Ohio.

PHOTOGRAPH NEEDED: Stars over sea, no land. Will buy for publication. Science Editor, Artists and Writers Guild, 630 Fifth Ave., New York 20, N. Y.

REFLECTOR, 8″, beral coated, cast-iron equatorial mount, synchronous drive, finder, 3 eyepieces, caster dolly. $185.00, plus transportation. C. Johnson, 48 Roberts St., Watertown, Conn.

NOW! You can see with both eyes while observing! Transform your telescope to get the results of giant binoculars by using the Brayton Binocular Eyepiece Holder (see page 607, October issue of *Sky and Telescope*). Brochure on request. Brayton Optical Exchange, 120 Beachway, Monterey, Calif.

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WANTED: Volumes I through IX of *Sky and Telescope*. State numbers available, price, and condition. February and November, 1952, issues wanted also. James Brown, 1409 Belmead Drive, Kingsport, Tenn.

CANADIAN AMATEURS: America's best-selling line of refracting telescopes and accessories, now available from Canada's largest optical specialists. Save customs clearance and extra duty. Carsen Instruments, Ltd., 88 Tycos Drive, Toronto 10, Canada.

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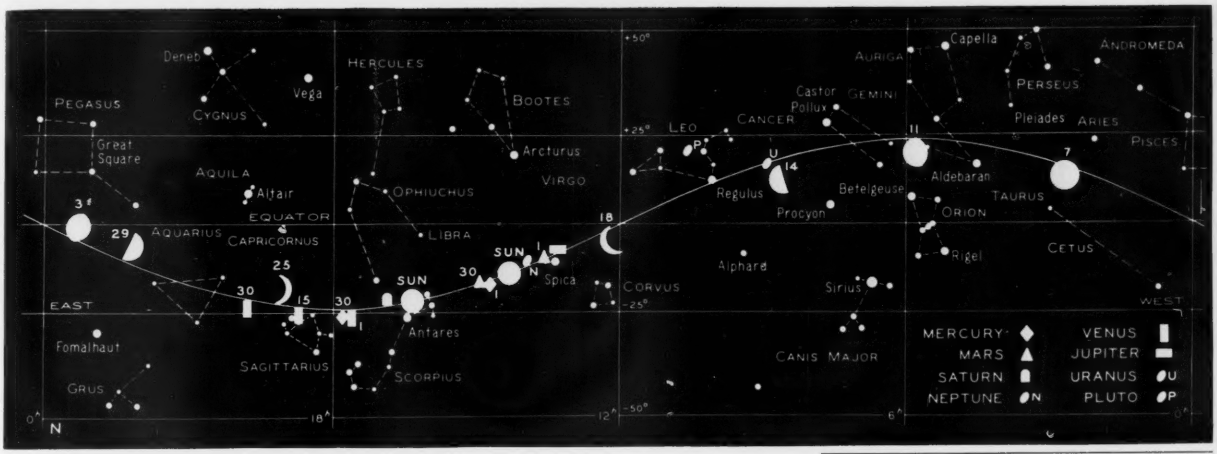


THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month or for other dates shown. All positions are for 0^h Universal time on the respective dates.

Mercury will be in the evening sky all month, but poorly situated for viewing. It may be observed during the last few days of November as a −0.3-magnitude object, setting one hour after the sun.

Venus' angular distance from the sun attains a maximum of 47° 14′ on November 18th, the planet then being at greatest eastern elongation. On that date it will be of magnitude −4.0, a brilliant white object in Sagittarius setting in the southwestern sky three hours after the sun. Telescopically, Venus will present a half-illuminated disk 25.1 seconds of arc in diameter.

There will be a close conjunction with the 6.5-magnitude star 86B Sagittarii on the 11th, but the minimum separation of about one diameter of the planet will be at 13:11 UT, during daylight hours for the Americas.

The moon will be totally eclipsed on November 7th as seen from eastern Asia, the Pacific, and the western part of North America. For details see page 21 of this issue.

Mars, now 2nd magnitude, rises two hours before the sun by the end of the month. The reddish planet is traveling rapidly eastward from Virgo into Libra. A very close conjunction with Lambda Virginis, magnitude 4.6, occurs on November 18th at 8:59 UT, Mars passing only about four seconds of arc from the star. Closest approach will take place before Mars rises for observers in the United States.

Jupiter is viewed rising in the east nearly three hours ahead of the sun in midmonth. The giant yellow planet is moving eastward in Virgo, and will be $3\frac{1}{2}$° north of Spica on the 21st.

Saturn may be seen only early in November, low in the southwestern sky. On the 7th it sets $1\frac{1}{2}$ hours after sundown, appearing of magnitude +0.7.

Uranus rises about midnight, passing western quadrature with the sun on November 4th. The planet's position among the stars changes very little, because retrograde motion begins on the 17th. Uranus can be found in binoculars as a 6th-magnitude object about 4° east of Delta Cancri.

Neptune, in the morning sky, is too near the sun to be seen this month.

MOON PHASES AND DISTANCE

Full moon	November 7, 14:32
Last quarter	November 14, 21:59
New moon	November 21, 16:19
First quarter	November 29, 6:57
Full moon	December 7, 6:16

	November	Distance	Diameter
Apogee	2, 12^h	251,700 mi.	29′ 30″
Perigee	18, 11^h	227,700 mi.	32′ 37″
Apogee	30, 7^h	251,300 mi.	29′ 33″
	December		
Perigee	14, 5^h	230,100 mi.	32′ 16″

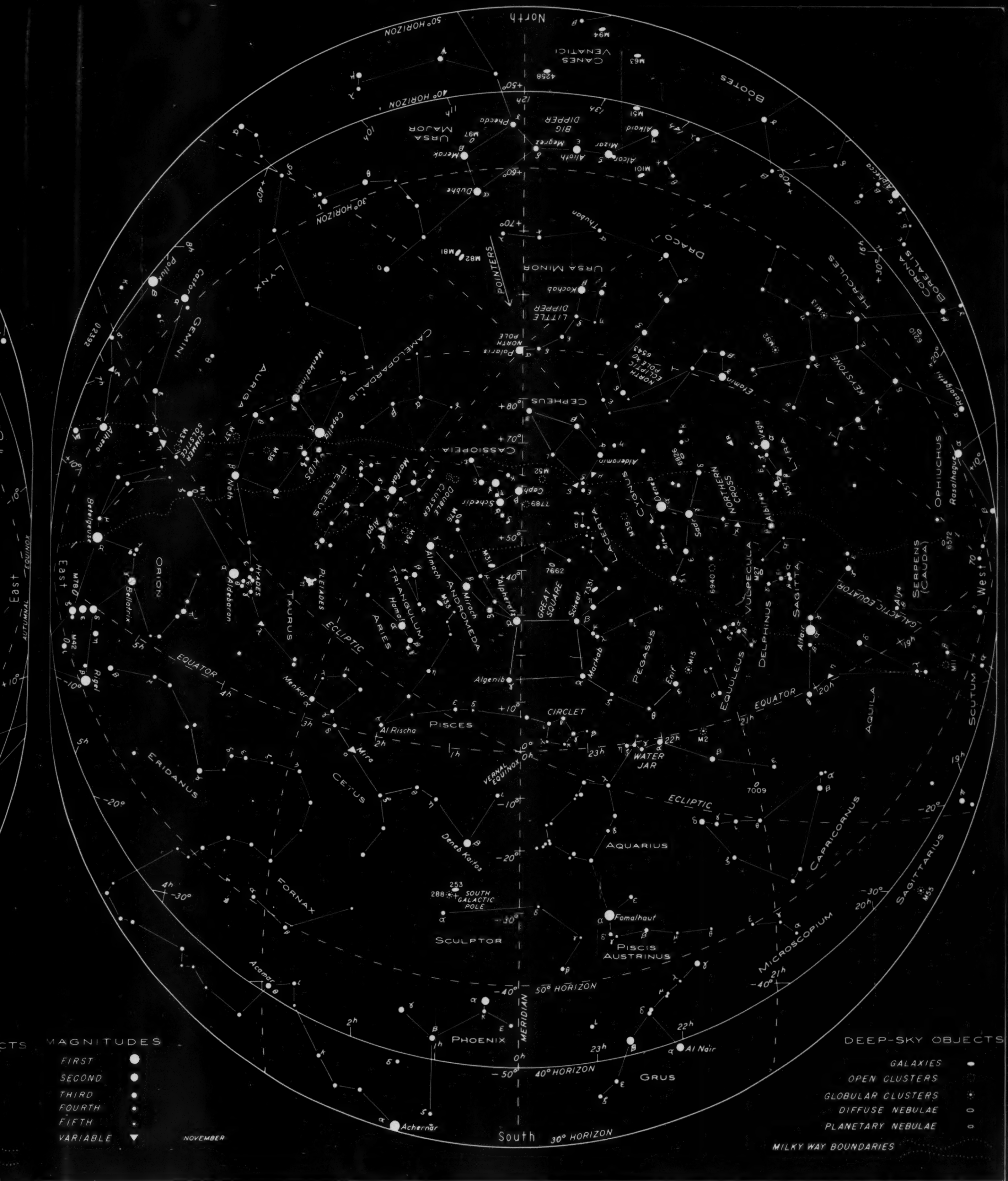
UNIVERSAL TIME (UT)

TIMES used in Celestial Calendar are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, in which case the result is your standard time on the day preceding the Greenwich date shown.

SOUTHERN STARS

The sky as seen from latitudes 20° to 40° south, at 11 p.m. and 10 p.m., local time, on the 7th and 23rd of January, respectively; also at 9 p.m. and 8 p.m. on February 6th and 21st. For other dates, add or subtract ½ hour per week.

Speaking of star-people appearing upside down in the Southern Hemisphere, on this chart some very famous ones are now seen that way: Orion, Auriga, Perseus, while even the Twins of Gemini have their feet higher than their heads, the stars Castor and Pollux.



STARS FOR NOVEMBER

The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of November, respectively; also, at 7 p.m. and 6 p.m. on December 7th and 23rd. For other dates, add or subtract ½ hour per week.

As the large bird constellations of our northern summer, Aquila the Eagle and Cygnus the Swan, fly down the western evening sky, two giant animals, Taurus the Bull and Cetus, monster of the deep, dominate the heavens in the east, pursued by Orion the Hunter.

See pages 28 and 29.